Requested Patent: WO0103366A1

Title:

APPARATUS AND METHOD FOR ENCODING/DECODING TRANSPORT FORMAT COMBINATION INDICATOR IN CDMA MOBILE COMMUNICATION SYSTEM ;

Abstracted Patent: WO0103366 ;

Publication Date: 2001-01-11 ;

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Application Number: WO2000KR00731 20000706 ;

Priority Number(s): KR19990027932 19990706 ;

IPC Classification: H04L9/06 ;

Equivalents: AU5854300, BR0012179, EP1188269 (WO0103366), JP2003503951T ;

ABSTRACT:

An apparatus and method for encoding/decoding a transport format combination indicator (TFCI) in a CDMA mobile communication system. In the TFCI encoding apparatus, a one-bit generator generates a sequence having the same symbols. A basis orthogonal sequence generator generates a plurality of basis orthogonal sequences. A basis mask sequence generator generates a plurality of basis mask sequences. An operation unit receives TFCI bits that are divided into a first information part representing biorthogonal sequence conversion, a second information part representing orthogonal sequence conversion, and a third information part representing mask sequence conversion and combines an orthogonal sequence selected from the basis orthogonal sequence based on the second information, a biorthogonal sequence obtained by combining the selected orthogonal sequence with the same symbols selected based on the first information part, and a mask sequence selected based on the biorthogonal sequence and the third information part, thereby generating a TFCI sequence.

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
11 January 2001 (11.01.2001)

PCT

(10) International Publication Number
WO 01/03366 A1

(51) International Patent Classification[7]: H04L 9/06

(21) International Application Number: PCT/KR00/00731

(22) International Filing Date: 6 July 2000 (06.07.2000)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
1999/27932 6 July 1999 (06.07.1999) KR

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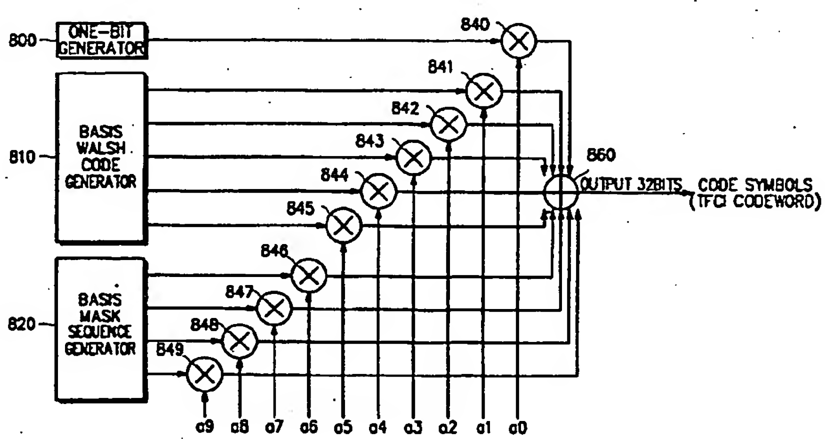
(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published:
— *With international search report.*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: APPARATUS AND METHOD FOR ENCODING/DECODING TRANSPORT FORMAT COMBINATION INDICATOR IN CDMA MOBILE COMMUNICATION SYSTEM



(57) Abstract: An apparatus and method for encoding/decoding a transport format combination indicator (TFCI) in a CDMA mobile communication system. In the TFCI encoding apparatus, a one-bit generator generates a sequence having the same symbols. A basis orthogonal sequence generator generates a plurality of basis orthogonal sequences. A basis mask sequence generator generates a plurality of basis mask sequences. An operation unit receives TFCI bits that are divided into a first information part representing biorthogonal sequence conversion, a second information part representing orthogonal sequence conversion, and a third information part representing mask sequence conversion and combines an orthogonal sequence selected from the basis orthogonal sequence based on the second information, a biorthogonal sequence obtained by combining the selected orthogonal sequence with the same symbols selected based on the first information part, and a mask sequence selected based on the biorthogonal sequence and the third information part, thereby generating a TFCI sequence.

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APPARATUS AND METHOD FOR ENCODING/DECODING TRANSPORT FORMAT COMBINATION INDICATOR IN CDMA MOBILE COMMUNICATION SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to an information transmitting apparatus and method in an IMT 2000 system, and in particular, to an apparatus and method for transmitting a transport format combination indicator (TFCI).

2. Description of the Related Art

A CDMA mobile communication system (hereinafter, referred to as an IMT 2000 system) generally transmits frames that provide a voice service, an image service, a character service on a physical channel such as a dedicated physical data channel (DPDCH) at a fixed or variable data rate. In the case where the data frames which include that sort of services are transmitted at a fixed data rate, there is no need to inform a receiver of the spreading rate of each data frame. On the other hand, if the data frames are transmitted at a variable data rate, which implies that each data frame has a different data rate, a transmitter should inform the receiver of the spreading rate of each data frame determined by its data rate. A data rate is proportional to a data transmission rate and the data transmission rate is inversely proportional to a spreading rate in a general IMT 2000 system.

For transmission of data frames at a variable data rate, a TFCI field of a DPCCH informs a receiver of the data rate of the current service frame. The TFCI field includes a TFCI indicating a lot of information including the data rate of a service frame. The TFCI is information that helps a voice or data service to reliably be provided.

FIGs. 1A to 1D illustrate examples of applications of a TFCI. FIG. 1A illustrates application of the TFCI to an uplink DPDCH and an uplink dedicated physical control channel (DPCCH). FIG. 1B illustrates application of the TFCI to a random access channel (RACH). FIG. 1C illustrates application of the TFCI to a downlink DPDCH and a downlink DPCCH. FIG. 1D illustrates application of the TFCI to a secondary common control physical channel (SCCPCH).

Referring to FIGs. 1A to 1D, one frame is comprised of 16 slots and each slot has a TFCI field. Thus, one frame includes 16 TFCI fields. A TFCI field includes N_{TFCI} bits and a TFCI generally has 32 bits in a frame. To transmit the 32-bit TFCI in one frame, 2 TFCI bits can be assigned to each of the 16 slots (T_{slot} = 0.625ms).

FIG. 2 is a block diagram of a base station transmitter in a general IMT 2000 system.

Referring to FIG. 2, multipliers 211, 231, and 232 multiply input signals by gain coefficients G_1, G_3, and G_5. Multipliers 221, 241, and 242 multiply TFCI codewords (TFCI code symbols) received from corresponding TFCI encoders by gain coefficients G_2, G_4, and G_6. The gain coefficients G_1 to G_6 may have different values according to service types or handover situations. The input signals include pilots and power control signals (TPCs) of a DPCCH and a DPDCH data. A multiplexer 212 inserts 32 bit TFCIcode symbols(TFCI codeword) received from the multiplier 221 into the TFCI fields as shown in FIG 1C. A multiplexer 242 inserts 32 bit TFCI code symbols received from the multiplier 241 into the TFCI fields. A multiplexer 252 inserts 32 bit TFCI code symbols received from the multiplier 242 into the TFCI fields. Insertion of TFCI code symbols into TFCI fields is shown in FIGs. 1A to 1D. The 32 code symbols are obtained by encoding TFCI bits(information bits) that define the data rate of a data signal on a corresponding data channel. 1st, 2nd, and 3rd serial to parallel converters (S/Ps) 213, 233, and 234 separate the outputs of the multiplexers 212, 242, and 252 into I channels and Q channels. Multipliers 214, 222, and 235 to 238 multiply the outputs of the S/Ps 213, 233, and 234 by channelization codes C_{ch1}, C_{ch2}, and C_{ch3}. The channelization codes are orthogonal codes. A first summer 215 sums the outputs of the multipliers 214, 235, and 237 and generates an I channel signal and a second summer 223 sums the outputs of the multipliers 222, 236, and 238 and generates a Q channel signal. A phase shifter 224 shifts the phase of the Q channel signal received from the second summer 223 by 90°. A summer 216 adds the outputs of the first summer 215 and the phase shifter 224 and generates a complex signal I+jQ. A multiplier 217 scrambles the complex signal with a complex PN sequence C_{scramb} assigned to the base station. A signal processor(S/P) 218 separates the scrambled signal into an I channel and a Q channel. Low-pass filters (LPFs) 219 and 225 limits the bandwidths of the I channel and Q channel signals received from the S/P 218 by low-pass-filtering. Multipliers 220 and 226 multiply the outputs of the LPFs 219 and 225 by carriers $\cos(2\pi f_c t)$ and $\sin(2\pi f_c t)$, respectively, thereby transforming the outputs of the LPFs 219 and 225 to an RF (Radio

Frequency) band. A summer 227 sums the RF I channel and Q channel signals.

FIG. 3 is a block diagram of a mobile station transmitter in the general IMT 2000 system.

Referring to FIG. 3, multipliers 311, 321, and 323 multiply corresponding signals by channelization codes C_{ch1}, C_{ch2}, and C_{ch3}. Signals 1, 2, 3 are first, second and third DPDCH signal. An input signal 4 includes pilots and TPCs of a DPCCH.TFCI information bits are encoded into 32 bit TFCI code symbols by a TFCI encoder 309. A multiplier 310 inserts a 32 bit TFCI code symbols into the signal 4 as shown in FIG. 1A. A multiplier 325 multiplies multiplies a DPCCH signal which include TFCI code symbol received from the multiplier 310 by a channelization code C_{ch4}. The channelization codes C_{ch1} to C_{ch4} are orthogonal codes. The 32 TFCI code symbols are obtained by encoding TFCI information bits that define the data rate of the DPDCH signals. Multipliers 312, 322, 324, and 326 multiply the outputs of the multipliers 311, 321, 323, and 325 by gain coefficients G_1 to G_4, respectably. The gain coefficients G_1 to G_4 may have different values. A first summer 313 generates an I channel signal by adding the outputs of the multipliers 312 and 322. A second summer 327 generates a Q channel signal by adding the outputs of the multipliers 324 and 326. A phase shifter 328 shifts the phase of the Q channel signal received from the second summer 327 by 90°. A summer 314 adds the outputs of the first summer 313 and the phase shifter 328 and generates a complex signal I+jQ. A multiplier 315 scrambles the complex signal with a PN sequence C_{scramb} assigned to a base station. An S/P 329 divides the scrambled signal into an I channel and a Q channel. LPFs 316 and 330 low-pass-filter the I channel and Q channel signals received from the S/P 329 and generate signals with limited bandwidths. Multipliers 317 and 331 multiply the outputs of the LPFs 316 and 330 by carriers $\cos(2\pi f_c t)$ and $\sin(2\pi f_c t)$, respectively, thereby transforming the outputs of the LPFs 316 and 330 to an RF band. A summer 318 sums the RF I channel and Q channel signals.

TFCIs are categorized into a basic TFCI and an extended TFCI. The basic TFCI represents 1 to 64 different information including the data rates of corresponding data channels using 6 TFCI information bits, whereas the extended TFCI represents 1 to 128, 1 to 256, 1 to 512, or 1 to 1024 different information using 7, 8, 9 or 10 TFCI information bits. The extended TFCI has been suggested to satisfy the requirement of the IMT 2000 system for more various services. TFCI bits are essential for a receiver to receive data frames received from a transmitter. That is the reason why unreliable transmission of the TFCI information bits due to transmission errors lead to wrong

interpretation of the frames in the receiver. Therefore, the transmitter encodes the TFCI bits with an error correcting code prior to transmission so that the receiver can correct possibly generated errors in the TFCI.

FIG. 4A conceptionally illustrates a basic TFCI bits encoding structure in a conventional IMT 2000 system and FIG. 4B is an exemplary encoding table applied to a biorthogonal encoder shown in FIG. 4A. As stated above, the basic TFCI has 6 TFCI bits (hereinafter, referred to as basic TFCI bits) that indicate 1 to 64 different information.

Referring to FIGs. 4A and 4B, a biorthogonal encoder 402 receives basic TFCI bits and outputs 32 coded symbols(TFCI codeword or TFCI code symbol). The basic TFCI is basically expressed in 6 bits. Therefore, in the case where a basic TFCI bits of less than 6 bits are applied to the biorthogonal encoder 402, 0s are added to the left end, i.e., MSB (Most Significant Bit) of the basic TFCI bits to increase the number of the basic TFCI bits to 6. The biorthogonal encoder 402 has a predetermined encoding table as shown in FIG. 4B to output 32 coded symbols for the input of the 6 basic TFCI bits. As shown in FIG. 4B, the encoding table lists 32(32-symbol) orthogonal codewords $c_{32.1}$ to $c_{32.32}$ and 32 biorthogonal codewords $\overline{c_{32.1}}$ to $\overline{c_{32.32}}$ that are the complements of the codewords $c_{32.1}$ to $c_{32.32}$. If the LSB (Least Significant Bit) of the basic TFCI is 1, the biorthogonal encoder 402 selects out of the 32 biorthogonal codewords. If the LSB is 0, the biorthogonal encoder 402 selects out of the 32 orthogonal codewords. One of the selected orthogonal codewords or biorthogonal codewords is then selected based on the other TFCI bits.

A TFCI codeword should have powerful error correction capability as stated before. The error correction capability of binary linear codes depends on the minimum distance (dmin) between the binary linear codes. A minimum distance for optimal binary linear codes is described in "An Updated Table of Minimum-Distance Bounds for Binary Linear Codes", A.E. Brouwer and Tom Verhoeff, IEEE Transactions on Information Theory, vol. 39, No. 2, March 1993 (hereinafter, referred to as reference 1).

Reference 1 gives 16 as a minimum distance for binary linear codes by which 32 bits are output for the input of 6 bits. TFCI codewords output from the biorthogonal encoder 402 has a minimum distance of 16, which implies that the TFCI codewords are optimal codes.

FIG. 5A conceptionally illustrates an extended TFCI bits encoding structure in the conventional IMT 2000 system, FIG. 5B is an exemplary algorithm of distributing TFCI bits in a controller shown in FIG. 5A, and FIG. 5C illustrates an exemplary encoding table applied to biorthogonal encoders shown in FIG. 5A. An extended TFCI is also defined by the number of TFCI bits. That is, the extended TFCI includes 7, 8, 9 or 10 TFCI bits (hereinafter, referred to as extended TFCI bits) that represent 1 to 128, 1 to 256, 1 to 512, or 1 to 1024 different information, as stated before.

Referring to FIGs. 5A, 5B, and 5C, a controller 500 divides TFCI bits into two halves. For example, for the input of 10 extended TFCI bits, the controller 500 outputs the first half of the extended TFCI as first TFCI bits (word 1) and the last half as second TFCI bits (word 2). The extended TFCI are basically expressed in 10 bits. Therefore, in the case where an extended TFCI bits of less than 10 bits are input, the controller 500 adds 0s to the MSB of the extended TFCI bits to represent the extended TFCI in 10 bits. Then, the controller 500 divides the 10 extended TFCI bits into word 1 and word 2. Word 1 and word 2 are fed to biorthogonal encoders 502 and 504, respectively. A method of separating the extended TFCI bits a_1 to a_{10} into word 1 and word 2 is illustrated in FIG. 5B.

The biorthogonal encoder 502 generates a first TFCI codeword having 16 symbols by encoding word 1 received from the controller 500. The biorthogonal encoder 504 generates a second TFCI codeword having 16 symbols by encoding word 2 received from the controller 500. The biorthogonal encoders 502 and 504 have predetermined encoding tables to output the 16-symbol TFCI codewords for the two 5-bit TFCI inputs (word 1 and word 2). An exemplary encoding table is illustrated in FIG. 5C. As shown in FIG. 5C, the encoding table lists 16 orthogonal codewords of length 16 bits $c_{16.1}$ to $c_{16.16}$ and biorthogonal codewords $\overline{c_{16.1}}$ to $\overline{c_{16.16}}$ that are the complements of the 16 orthogonal codewords. If the LSB of 5 TFCI bits is 1, a biorthogonal encoder (502 or 504) selects the 16 biorthogonal codewords. If the LSB is 0, the biorthogonal encoder selects the 16 orthogonal codewords. Then, the biorthogonal encoder selects one of the selected orthogonal codewords or biorthogonal codewords based on the other TFCI bits and outputs the selected codeword as the first or second TFCI codeword.

A multiplexer 510 multiplexes the first and second TFCI codewords to a final 32-symbol TFCI codeword.

Upon receipt of the 32-symbol TFCI codeword, a receiver decodes the TFCI codeword separately in halves (word 1 and word 2) and obtains 10 TFCI bits by combining the two decoded 5-bit TFCI halves. In this situation, a possible error even in one of the decoded 5-bit TFCI output during decoding leads to an error over the 10 TFCI bits.

An extended TFCI codeword also should have a powerful error correction capability. To do so, the extended TFCI codeword should have the minimum distance as suggested in reference 1.

In consideration of the number 10 of extended TFCI bits and the number 32 of the symbols of a TFCI codeword, reference 1 gives 12 as a minimum distance for an optimal code. Yet, a TFCI codeword output from the structure shown in FIG. 5A has a minimum distance of 8 because an error in at least one of word 1 and word 2 during decoding results in an error in the whole 10 TFCI bits. That is, although extended TFCI bits are encoded separately in halves, a minimum distance between final TFCI codewords is equal to a minimum distance 8 between codeword outputs of the biorthogonal encoders 502 and 504.

Therefore, a TFCI codeword transmitted from the encoding structure shown in FIG. 5A is not optimal, which may increase an error probability of TFCI bits in the same radio channel environment. With the increase of the TFCI bit error probability, the receiver misjudges the data rate of received data frames and decodes the data frames with an increased error rate, thereby decreasing the efficiency of the IMT 2000 system.

According to the conventional technology, separate hardware structures are required to support the basic TFCI and the extended TFCI. As a result, constraints are imposed on implementation of an IMT 2000 system in terms of cost and system size.

SUMMARY OF THE INVENTION

It is, therefore, an object of the present invention to provide an apparatus and method for encoding an extended TFCI in an IMT 2000 system.

It is also an object of the present invention to provide an apparatus and method for encoding a basic TFCI and an extended TFCI compatibly in an IMT 2000 system.

It is another object of the present invention to provide an apparatus and method for decoding an extended TFCI in an IMT 2000 system.

It is still another object of the present invention to provide an apparatus and method for decoding a basic TFCI and an extended TFCI compatibly in an IMT 2000 system.

It is yet another object of the present invention to provide an apparatus and method for generating an optimal code by encoding an extended TFCI in an IMT 2000 system.

It is a further object of the present invention to provide a method of generating mask sequences for use in encoding/decoding an extended TFCI in an IMT 2000 system.

To achieve the above objects, there is provided a TFCI encoding/decoding apparatus and method in a CDMA mobile communication system. In the TFCI encoding apparatus, a one-bit generator generates a sequence having the same symbols. A basis orthogonal sequence generator generates a plurality of basis orthogonal sequences. A basis mask sequence generator generates a plurality of basis mask sequences. An operation unit receives TFCI bits that are divided into a 1st information part representing biorthogonal sequence conversion, a 2nd information part representing orthogonal sequence conversion, and a 3rd information part representing mask sequence conversion and combines an orthogonal sequence selected from the basis orthogonal sequence based on the 2nd information, a biorthogonal sequence obtained by combining the selected orthogonal sequence with the same symbols selected based on the 1st information part, and a mask sequence selected based on the biorthogonal code sequence and the 3rd information part, thereby generating a TFCI sequence.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features and advantages of the present invention will become more apparent from the following detailed description when taken in conjunction with the accompanying drawings in which:

FIGs. 1A to 1D illustrate exemplary applications of a TFCI to channel frames in a general IMT 2000 system;

FIG. 2 is a block diagram of a base station transmitter in the general IMT 2000 system;

FIG. 3 is a block diagram of a mobile station transmitter in the general IMT 2000 system;

FIG. 4A conceptionally illustrates a basic TFCI encoding structure in a conventional IMT 2000 system;

FIG. 4B is an example of an encoding table used in a biorthogonal encoder shown in FIG. 4A;

FIG. 5A conceptionally illustrates an extended TFCI encoding structure in the conventional IMT 2000 system;

FIG. 5B is an example of an algorithm of distributing TFCI bits in a controller shown in FIG. 5A;

FIG. 5C is an example of an encoding table used in biorthogonal encoders shown in FIG. 5A;

FIG. 6 conceptionally illustrates a TFCI encoding structure in an IMT 2000 system according to the present invention;

FIG. 7 is a flowchart illustrating an embodiment of a mask sequence generating procedure for TFCI encoding in the IMT 2000 system according to the present invention;

FIG. 8 is a block diagram of an embodiment of a TFCI encoding apparatus in the IMT 2000 system according to the present invention;

FIG. 9 is a block diagram of an embodiment of a TFCI decoding apparatus in the IMT 2000 system according to the present invention;

FIG. 10 is a flowchart illustrating a control operation of a correlation comparator shown in FIG. 9;

FIG. 11 is a flowchart illustrating an embodiment of a TFCI encoding procedure in the IMT 2000 system according to the present invention;

FIG. 12 is a flowchart illustrating another embodiment of the TFCI encoding procedure in the IMT 2000 system according to the present invention;

FIG. 13 illustrates an embodiment of the structures of orthogonal sequences and mask sequences determined by a TFCI according to the present invention;

FIG. 14 is a block diagram of another embodiment of the TFCI encoding apparatus in the IMT 2000 system according to the present invention;

FIG. 15 is a block diagram of another embodiment of the TFCI decoding apparatus in the IMT 2000 system according to the present invention;

FIG. 16 is a flowchart illustrating another embodiment of the TFCI encoding procedure in the IMT 2000 system according to the present invention; and

FIG. 17 is a block diagram of a third embodiment of the TFCI decoding apparatus in the IMT 2000 system according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Preferred embodiments of the present invention will be described herein below with reference to the accompanying drawings. In the following description, well-known functions or constructions are not described in detail since they would obscure the invention in unnecessary detail.

The present invention is directed to a TFCI encoding concept of outputting final code symbols (a TFCI codeword) by adding first code symbols (a first TFCI codeword) resulting from first TFCI bits and second code symbols (a second TFCI codeword) resulting from second TFCI bits in an IMT 2000 system. The TFCI encoding concept is shown in FIG. 6. Here, a biorthogonal sequence and a mask sequence are given as the first TFCI codeword and the second TFCI codeword, respectively.

Referring to FIG.6, TFCI bits are separated into the first TFCI bits and the second TFCI bits. A mask sequence generator 602 generates a predetermined mask sequence by encoding the second TFCI bits and a biorthogonal sequence generator 604 generates a predetermined biorthogonal sequence by encoding the first TFCI bits. An adder 610 adds the mask sequence and the biorthogonal sequence and outputs final code symbols (a TFCI codeword). The mask sequence generator 602 may have an encoding table that lists mask sequences for all possible second TFCI bits. The biorthogonal sequence generator 604 may also have an encoding table that lists biorthogonal sequences for all possible first TFCI bits.

As described above, mask sequences and a mask sequence generating method should be defined to implement the present invention. Walsh codes are given as orthogonal sequences by way of example in embodiments of the present invention.

1. Mask Sequence Generating Method

The present invention pertains to encoding and decoding of TFCI bits and use of an extended Reed Muller code in an IMT 2000 system. For this purpose, predetermined sequences are used and the sequences should have a minimum distance that ensures excellent error correction performance.

A significant parameter that determines the performance or capability of a linear

error correcting code is a minimum distance between codewords of the error correcting code. The Hamming weight of a codeword is the number of its symbols other than 0. If a codeword is given as "0111", its Hamming weight is 3. The smallest Hamming weight of a codeword except all "0" codeword is called a minimum weight and the minimum distance of each binary linear code is equal to the minimum weight. A linear error correcting code has a better error correcting performance as its minimum distance is increased. For details, see "The Theory of Error-Correcting Codes", F.J. Macwilliams and N.J.A. Sloane, North-Holland (hereinafter, referred to as reference 2).

An extended Reed Muller code can be derived from a set of sequences each being the sum of the elements of an m-sequence and a predetermined sequence. To use the sequence set as a linear error correcting code, the sequence set should have a large minimum distance. Such sequence sets include a Kasami sequence set, a Gold sequence set, and a Kerdock sequence set. If the total length of a sequence in such a sequence set is $L= 2^{2m}$, a minimum distance = $(2^{2m}- 2^{m})/2$. For $L = 2^{2m+1}$, the minimum distance = $(2^{2m+1}- 2^{2m})/2$. That is, if $L = 32$, the minimum distance = 12.

A description will be made of a method of generating a linear error correcting code with excellent performance, i.e., an extended error correcting code (Walsh codes and mask sequences).

According to a coding theory, there is a column transposition function for making Walsh codes from m-sequences in a group which has been formed by cyclically shifting an originating m-sequence by one to 'n' times, where the 'n' is a length of the m-sequence. In other words, each of the m-sequences is formed by cyclically shifting the originating m-sequence by a particular number of times. The column transposition function is a converting function which converts the swquences in the m-sequence group to Walsh codes. We assume there is a sequence such as a Gold sequence or a Kasami sequence which is formed by adding the originating m-sequence with another originating m-sequence. Another group of m-sequences is similarly formed by cyclically shifting the other originating m-sequence one to 'n' times, where 'n' is the length of the predetermined sequence. Afterwards, a reverse column transposition function is applied to the second group of m-sequences formed from the other originating m-sequence. The application of the reverse column transposition function to the second group of m-sequences creates another set of sequences which shall be defined as mask sequences.

In an embodiment of the present invention, a mask sequence generating method is described in connection with generation of a (2^n, n+k) code (extended Reed Muller code) (here, k = 1, ..., n+1) using a Gold sequence set. The (2^n, n+k) code represents output of a 2^n-symbol TFCI codeword for the input of (n+k) TFCI bits (input information bits). It is well known that a Gold sequence can be expressed as the sum of two different m-sequences. To generate the (2^n, n+k) code, therefore, Gold sequences of length (2^n-1) should be produced. Here, a Gold sequence is the sum of two m-sequences $m_1(t)$ and $m_2(t)$ that are generated from generator polynomials f1(x) and f2(x). Given the generator polynomials f1(x) and f2(x), the m-sequences $m_1(t)$ and $m_2(t)$ are computed using a Trace function.

$$m_1(t) = Tr(A\alpha^t) \qquad t = 0, 1, ..., 30 \text{ and}$$

$$Tr(a) = \sum_{k=0}^{n-1} a^{2^k}, \qquad a \in GF(2^n) \qquad \text{..... (Eq. 1)}$$

where A is determined by the initial value of an m-sequence, α is the root of the polynomial, and n is the order of the polynomial.

FIG. 7 is a flowchart illustrating a mask sequence generating procedure for use in generating a (2^n, n+k) code from a Gold sequence set.

Referring to FIG. 7, m-sequences $m_1(t)$ and $m_2(t)$ are generated in Eq. 1 using the generator polynomials f1(x) and f2(x), respectively in step 710. In step 712, a sequence transposition function σ(t) is calculated to make Walsh codes from a sequence set having m-sequences formed by cyclically shifting $m_2(t)$ 0 to n-2 times where all '0' column is inserted in front of the m-sequences made from $m_2(t)$, as shown below:

$$\sigma: \{0, 1, 2, ..., 2^n-2\} \rightarrow \{1, 2, 3, ..., 2^n-1\}$$

$$\sigma(t) = \sum_{i=0}^{n-1} m_2(t+i)2^{n-1-i} \qquad t = 0, 1, 2, ... \qquad \text{..... (Eq. 2)}$$

A set of 31 sequences produced by cyclically shifting the m-sequence $m_1(t)$ 0 to 30 times are column-transposed with the use of $\sigma^{-1}(t)+2$ derived from the reverse function of σ(t) in step 730. Then, 0s are added to the start of each of the resulting column-transposed sequences to make the length of the sequence 2^n. Thus, a set $d_i(t)$ of (2^n-1) sequences of length 2^n (i = 0, ..., 2^n-2, t = 1, ..., 2^n) are generated.

$$\{d_i(t)\ |t = 1, ..., 2^n,\ i = 0, ..., 2^n - 2\}$$
$$d_i(t) = \begin{pmatrix} 0, & if,\ t = 1 \\ m_1(\sigma^{-1}(t+i)+2), & if,\ t = 2,3,\ldots,2^n \end{pmatrix} \quad \ldots\ldots \text{(Eq. 3)}$$

A plurality of $d_i(t)$ are mask functions that can be used as 31 masks.

$d_i(t)$ is characterized in that two different masks among the above masks are added to one of (2^n-1) masks except for the two masks. To further generalize it, each of the (2^n-1) masks can be expressed as the sum of at least two of particular n masks. The n masks are called basis mask sequences. When the $(2^n, n+k)$ code is to be generated, the total number of necessary codewords is 2^{n+k} for n+k input information bits (TFCI bits). The number of 2^n orthogonal sequences (Walsh sequences) and their complements, i.e. biorthogonal sequences, is $2^n \times 2 = 2^{n+1}$. $2^{k-1}-1(=(2^{n+k}/2^{n+1})-1)$ masks that are not 0s are needed for generation of the $(2^n, n+k)$ code. Here, the $2^{k-1}-1$ masks can be expressed by the use of k−1 basis mask sequences, as stated before.

Now, a description will be given of a method of selecting the k−1 basis mask sequences. The m-sequence $m_1(t)$ is cyclically shifted 0 to 2^{n-1} times to generate a set of sequences in step 730 of FIG. 7. Here, an m-sequence obtained by cyclically shifting the m-sequence $m_1(t)$ i times is expressed as $Tr(\alpha^i \cdot \alpha^t)$ according to Eq.1. That is, a set of sequences are generated by cyclically shifting the m-sequence $m_1(t)$ 0 to 30 times with respect to an initial sequence $A = \{1, \alpha, ..., \alpha^{2n-2}\}$. Here, linearly independent k−1 basis elements are found from the Galois elements 1, α, ..., α^{2^n-2} and mask sequences corresponding to the output sequences of a Trace function with the k−1 basis elements as an initial sequence become basis mask sequences. A linear independence condition is expressed as

$\alpha_1, ..., \alpha_{k-1}$: linearly independent
$$\Leftrightarrow c_1\alpha_1 + c_2\alpha_2 + ... + c_{k-1}\alpha_{k-1} \neq 0,\quad \forall c_1, c_2, ..., c_{k-1} \quad \ldots\ldots \text{(Eq. 4)}$$

To describe the above generalized mask function generation method in detail, how to generate a (32, 10) code using a Gold sequence set will be described referring to FIG. 7. It is well known that a Gold sequence is expressed as the sum of different predetermined m-sequences. Therefore, a Gold sequence of length 31 should be

generated first in order to generate the intended (32, 10) code. The Gold sequence is the sum of two m-sequences generated respectively from polynomials x^5+x^2+1 and x^5+x^4+x+1. Given a corresponding generator polynomial, each of the m-sequences $m_1(t)$ and $m_2(t)$ is computed using a Trace function by

$$m_1(t) = Tr(A\alpha^t) \qquad t = 0, 1, ..., 30 \text{ and}$$

$$Tr(a) = \sum_{n=0}^{4} a^{2^n}, \qquad a \in GF(2^5) \qquad \text{.....(Eq. 5)}$$

where A is determined by the initial value of the m-sequence, α is the root of the polynomial, and n is the order of the polynomial, here 5.

FIG. 7 illustrates the mask function generating procedure to generate the (32, 10) code.

Referring to FIG. 7, m-sequences $m_1(t)$ and $m_2(t)$ are generated in Eq. 1 using the generator polynomials f1(x) and f2(x), respectively in step 710. In step 712, the column transposition function σ(t) is calculated to make a Walsh code of the m-sequence $m_2(t)$ by

$$\sigma: \{0, 1, 2, ..., 30\} \rightarrow \{1, 2, 3, ..., 31\}$$

$$\sigma(t) = \sum_{i=0}^{4} m_2(t-i)2^{4-i} \qquad \text{.....(Eq. 6)}$$

Then, a set of 31 sequences produced by cyclically shifting the m-sequence $m_1(t)$ 0 to 30 times are column-transposed with the use of $\sigma^{-1}(t)+2$ derived from the reverse function of σ(t) in step 730. Then, 0s are added to the start of each of the resulting sequence-transposed sequences to make the length of the sequence 31. Thus, 31 $d_i(t)$ of length 32 are generated. Here, if i = 0, ..., 31, t = 1, ..., 32. The sequences set generated in step 730 can be expressed as

$$\{d_i(t) \mid t = 1, ..., 32,\ i = 0, ..., 30\}$$

$$d_i(t) = \begin{pmatrix} 0, & if,\ t = 1 \\ m_1(\sigma^{-1}(t+i)+2), & if,\ t = 2,3,\ldots,32 \end{pmatrix} \qquad \text{......(Eq. 7)}$$

A plurality of $d_i(t)$ obtained from Eq. 7 can be used as 31 mask sequences.

$d_i(t)$ is characterized in that two different masks among the above masks are added to one of the 31 masks except for the two masks. In other words, each of the 31 masks can be expressed as a sum of 5 particular masks. These 5 masks are basis mask sequences.

When the (32, 10) code is to be generated, the total number of necessary codewords is $2^n = 1024$ for all possible 10 input information bits (TFCI bits). The number of biorthogonal sequences of length 32 is 32 x 2 = 64. 15 masks are needed to generate the (32, 10) code. The 15 masks can be expressed as combinations of 4 basis mask sequences.

Now, a description will be given of a method of selecting the 4 basis mask sequences. An m-sequence obtained by cyclically shifting the m-sequence $m_1(t)$ i times is expressed as $Tr(\alpha^i \cdot \alpha^t)$ according to Eq.1. That is, a set of sequences are generated by cyclically shifting the m-sequence $m_1(t)$ 0 to 30 times with respect to an initial sequence $A = \{1, \alpha, ..., \alpha^{2n-2}\}$. Here, 4 linearly independent basis elements are found from the Galois elements $1, \alpha, ..., \alpha^{2n-2}$ and mask sequences corresponding to the output sequences of a Trace function with the 4 basis elements as an initial sequence becoming basis mask sequences. A linear independence condition is expressed as

$$\alpha, \beta, \gamma, \delta: \text{linearly independent}$$
$$\Leftrightarrow c_1\alpha + c_2\beta + c_3\gamma, + c_4\delta \neq 0, \quad \forall c_1, c_2, c_3, c_4 \qquad \text{..... (Eq. 8)}$$

In fact, $1, \alpha, \alpha^2, \alpha^3$ in the Galois $GF(2^5)$ are polynomial sub-bases that are well known as four linearly independent elements. By replacing the variable A in Eq. 1 with the polynomial bases, four basis mask sequences M1, M2, M4, and M8 are achieved.

M1 = 00101000011000111111000001110111
M2 = 00000001110011010110110111000111
M4 = 00001010111110010001101100101011
M8 = 00011100001101110010111101010001

There will herein below be given a description of an apparatus and method for encoding/decoding a TFCI using basis mask sequences as obtained in the above manner in an IMT 2000 system according to embodiments of the present invention.

2. First Embodiment of Encoding/Decoding Apparatus and Method

FIGs. 8 and 9 are block diagrams of TFCI encoding and decoding apparatuses in an IMT 2000 system according to an embodiment of the present invention.

Referring to FIG. 8, 10 TFCI bits a0 to a9 are applied to corresponding multipliers 840 to 849. A one-bit generator 800 continuously generates a predetermined code bit. That is, since the present invention deals with biorthogonal sequences, necessary bits are generated to make a biorthogonal sequence out of an orthogonal sequence. For example, the one-bit generator 800 generates bits having 1s to inverse an orthogonal sequence (i.e., a Walsh code) generated from a basis Walsh code generator 810 and thus generate a biorthogonal sequence. The basis Walsh code generator 810 generates basis Walsh codes of a predetermined length. The basis Walsh codes refer to Walsh codes from which all intended Walsh codes can be produced through arbitrary addition. For example, when Walsh codes of length 32 are used, the basis Walsh codes are 1st, 2nd, 4th, 8th, and 16th Walsh codes W1, W2, W4, W8, and W16, wherein:

W1:01010101010101010101010101010101
W2:00110011001100110011001100110011
W4: 00001111000011110000111100001111
W8: 00000000111111110000000011111111
W16: 00000000000000001111111111111111.

A basis mask sequence generator 820 generates a basis mask sequence of a predetermined length. A basis mask sequence generating method has already been described before and its details will not be described. If a mask sequence of length 32 is used, basis mask sequences are 1st, 2nd, 4th, and 8th mask sequences M1, M2, M4, M8, wherein:

M1: 00101000011000111111000001110111
M2: 00000001110011010110110111000111
M4: 00001010111110010001101100101011
M8: 00011100001101110010111101010001.

The multiplier 840 multiplies 1s output from the one-bit generator 800 by the input information bit a0 on a symbol basis.

The multiplier 841 multiplies the basis Walsh code W1 received from the basis Walsh code generator 810 by the input information bit a1. The multiplier 842 multiplies the basis Walsh code W2 received from the basis Walsh code generator 810 by the input

information bit a2. The multiplier 843 multiplies the basis Walsh code W4 received from the basis Walsh code generator 810 by the input information bit a3. The multiplier 844 multiplies the basis Walsh code W8 received from the basis Walsh code generator 810 by the input information bit a4. The multiplier 845 multiplies the basis Walsh code W16 received from the basis Walsh code generator 810 by the input information bit a5. The multipliers 841 to 845 multiply the received basis Walsh codes W1, W2, W4, W8, and W16 by their corresponding input information bits symbol by symbol.

Meanwhile, the multiplier 846 multiplies the basis mask sequence M1 by the input information bit a6. The multiplier 847 multiplies the basis mask sequence M2 by the input information bit a7. The multiplier 848 multiplies the basis mask sequence M4 by the input information bit a8. The multiplier 849 multiplies the basis mask sequence M8 by the input information bit a9. The multipliers 846 to 849 multiply the received basis mask sequences M1, M2, M4, and M8 by their corresponding input information bits symbol by symbol.

An adder 860 adds the encoded input information bits received from the multipliers 840 to 849 and outputs final code symbols of length 32 bits (a TFCI codeword). The length of the final code symbols (TFCI codeword) is determined by the lengths of the basis Walsh codes generated from the basis Walsh code generator 810 and the basis mask sequences generated from the basis mask sequence generator 820.

For example, if the input information bits a0 to a9 are "0111011000", the multiplier 840 multiplies 0 as a0 by 1s received from the one-bit generator 800 and generates 32 code symbols being all "0s". The multiplier 841 multiplies 1 as a1 by W1 received from the basis Walsh code generator 810 and generates code symbols "01010101010101010101010101010101". The multiplier 842 multiplies 1 as a2 by W2 received from the basis Walsh code generator 810 and generates code symbols "00110011001100110011001100110011". The multiplier 843 multiplies 1 as a3 by W4 received from the basis Walsh code generator 810 and generates code symbols "00001111000011110000111100001111". The multiplier 844 multiplies 0 as a4 by W8 received from the basis Walsh code generator 810 and generates 32 code symbols being all "0s". The multiplier 845 multiplies 1 as a5 by W16 received from the basis Walsh code generator 810 and generates "00000000000000001111111111111111". The multiplier 846 multiplies 1 as a6 by M1 received from the basis mask sequence generator 820 and generates "00101000011000111111000001110111". The multiplier 847 multiplies 0 as a7 by M2 received from the basis mask sequence generator 820 and

generates 32 code symbols being all 0s. The multiplier 848 multiplies 0 as a8 by M4 received from the basis mask sequence generator 820 and generates 32 code symbols being all 0s. The multiplier 849 multiplies 0 as a9 by M8 received from the basis mask sequence generator 820 and generates 32 code symbols being all 0s. The adder 860 adds the code symbols received from the multipliers 840 to 849 and outputs final code symbols "01000001000010100110011011100001". The final code symbols can be achieved by adding the basis Walsh codes W1, W2, W4 and W16 corresponding to the information bits 1s to the basis mask sequence M1 symbol by symbol. In other words, the basis Walsh codes W1, W2, W4 and W16 are summed to W23 and the Walsh code W23 and the basis mask sequence M1 are added to form the TFCI codeword (final code symbols) (=W23+M1) which is outputted from the adder 860.

FIG. 11 is a flowchart illustrating an embodiment of a TFCI encoding procedure in an IMT 2000 system according to the present invention.

Referring to FIG. 11, 10 input information bits (i.e., TFCI bits) are received and variables sum and j are set to an initial value 0 in step 1100. The variable sum indicates final code symbols, and j indicates the count number of final code symbols output after symbol-basis addition. In step 1110, it is determined whether j is 32 in view of the length 32 symbols of Walsh codes and mask sequences used for encoding the input information bits. Step 1110 is performed in order to check whether the input information bits are all encoded with the Walsh codes and the mask sequences symbol by symbol.

If j is not 32 in step 1110, which implies that the input information bits are not encoded completely with respect to all symbols of the Walsh codes, the mask sequences, j^{th} symbols W1(j), W2(j), W4(j), W8(j), and W16(j) of the basis Walsh codes W1, W2, W4, W8, and W16 and j^{th} symbols M1(j), M2(j), M4(j), and M8(j) of the basis mask sequences M1, M2, M4, and M8 are received in step 1120. Then, the received symbols are multiplied by the input information bits on a symbol basis and the symbol products are summed in step 1130. The sum becomes the variable sum.

Step 1130 can be expressed as

$$sum = a0 + a1 \cdot W1(j) + a2 \cdot W2(j) + a3 \cdot W4(j) + a4 \cdot W8(j) + a5 \cdot W16(j) + a6 \cdot M1(j) + a7 \cdot M2(j) + a8 \cdot M4(j) + a9 \cdot M8(j) \quad \ldots\ldots \text{(Eq. 9)}$$

As noted from Eq. 9, the input information bits are multiplied by corresponding symbols of the basis Walsh codes and basis mask sequences, symbol products are summed, and the sum becomes an intended code symbol.

In step 1140, sum indicating the achieved j^{th} code symbol, is output. j is increased by 1 in step 1150 and then the procedure returns to step 1110. Meanwhile, if j is 32 in step 1110, the encoding procedure ends.

The encoding apparatus of FIG. 8 according to the embodiment of the present invention can support extended TFCIs as well as basic TFCIs. Encoders for supporting an extended TFCI include a (32, 10) encoder, a (32, 9) encoder, and a (32, 7) encoder.

For the input of 10 input information bits, the (32, 10) encoder outputs a combination of 32 Walsh codes of length 32, 32 bi-orthogonal codes inverted from the Walsh codes, and 15 mask sequences. The 32 Walsh codes can be generated from combinations of 5 basis Walsh codes. The 32 bi-orthogonal codes can be obtained by adding 1 to the 32 symbols of each Walsh code. This results has the same effect as multiplication of -1 by the 32 Walsh codes viewed as real numbers. The 15 mask sequences can be achieved through combinations of 5 basis mask sequences. Therefore, a total of 1024 codewords can be produced from the (32, 10) encoder.

The (32, 9) encoder receives 9 input information bits and outputs a combination of 32 Walsh codes of length 32, 32 bi-orthogonal codes inverted from the Walsh codes, and 4 mask sequences. The 4 mask sequences are obtained by combing two of 4 basis mask sequences.

The (32, 7) encoder receives 7 input information bits and outputs a combination of 32 Walsh codes of length among the 1024 codewords, 32 bi-orthogonal codes inverted from the Walsh codes, and one of 4 basis mask sequences.

The above encoders for providing extended TFCIs have a minimum distance 12 and can be implemented by blocking input and output of at least of the 4 basis mask sequences generated from the basis mask sequences 820.

That is, the (32, 9) encoder can be implemented by blocking input and output of one of the four basis mask sequences generated from the basis mask sequence generator 820 shown in FIG. 8. The (32, 8) encoder can be implemented by blocking input and

output of two of the basis mask sequences generated from the basis mask sequence generator 820. The (32, 7) encoder can be implemented by blocking input and output of three of the basis mask sequences generated from the basis mask sequence generator 820. As described above, the encoding apparatus according to the embodiment of the present invention can encode flexibly according to the number of input information bits, that is, the number of TFCI bits to be transmitted and maximizes a minimum distance that determined the performance of the encoding apparatus.

Codewords in the above encoding apparatus are sequences obtained by combining 32 Walsh codes of length 32, 32 bi-orthogonal codes resulting from adding 1s to the Walsh codes, and 15 mask sequences of length 15. The structure of the codewords is shown in FIG. 13.

For better understanding of the TFC bits encoding procedure, Tables 1a to 1f list code symbols (TFCI codewords) versus 10 TFCI bits.

(Table 1a)

0000000000 :	0000000001 :
00000000000000000000000000000000	11111111111111111111111111111111
0000000010 :	0000000011 :
01010101010101010101010101010101	10101010101010101010101010101010
0000000100 :	0000000101 :
00110011001100110011001100110011	11001100110011001100110011001100
0000000110 :	0000000111 :
01100110011001100110011001100110	10011001100110011001100110011001
0000001000 :	0000001001 :
00001111000011110000111100001111	11110000111100001111000011110000
0000001010 :	0000001011 :
01011010010110100101101001011010	10100101101001011010010110100101
0000001100 :	0000001101 :
00111100001111000011110000111100	11000011110000111100001111000011
0000001110 :	0000001111 :
01101001011010010110100101101001	10010110100101101001011010010110
0000010000 :	0000010001 :
00000000111111110000000011111111	11111111000000001111111100000000
0000010010 :	0000010011 :

01010101101010100101010110101010 0000010100 :	10101010010101011010101001010101 0000010101 :
00110011110011000011001111001100 0000010110 :	11001100001100111100110000110011 0000010111 :
01100110100110010110011010011001 0000011000 :	10011001011001101001100101100110 0000011001 :
00001111111100000000111111110000 0000011010 :	11110000000011111111000000001111 0000011011 :
01011010101001010101101010100101 0000011100 :	10100101010110101010010101011010 0000011101 :
00111100110000110011110011000011 0000011110 :	11000011001111001100001100111100 0000011111 :
01101001100101100110100110010110 0000100000 :	10010110011010011001011001101001 0000100001 :
00000000000000001111111111111111 0000100010 :	11111111111111110000000000000000 0000100011 :
01010101010101011010101010101010 0000100100 :	10101010101010100101010101010101 0000100101 :
00110011001100111100110011001100 0000100110 :	11001100110011000011001100110011 0000100111 :
01100110011001101001100110011001 0000101000 :	10011001100110010110011001100110 0000101001 :
00001111000011111111000011110000 0000101010 :	11110000111100000000111100001111 0000101011 :
01011010010110101010010110100101 0000101100 :	10100101101001010101101001011010 0000101101 :
00111100001111001100001111000011 0000101110 :	11000011110000110011110000111100 0000101111 :
01101001011010011001011010010110 0000110000 :	10010110100101100110100101101001 0000110001 :
00000000111111111111111100000000 0000110010 :	11111111000000000000000011111111 0000110011 :
01010101101010101010101001010101 0000110100 :	10101010010101010101010110101010 0000110101 :
00110011110011001100110000110011 0000110110 :	11001100001100110011001111001100 0000110111 :

01100110100110011001100101100110	10011001011001100110011010011001
0000111000 :	0000111001 :
00001111111100001111000000001111	11110000000011110000111111110000
0000111010 :	0000111011 :
01011010101001011010010101011010	10100101010110100101101010100101
0000111100 :	0000111101 :
00111100110000111100001100111100	11000011001111000011110011000011
0000111110 :	0000111111 :
01101001100101101001011001101001	10010110011010010110100110010110
0001000000 :	0001000001 :
00101000011000111111000001110111	11010111100111000000111110001000
0001000010 :	0001000011 :
01111101001101101010010100100010	10000010110010010101101011011101
0001000100 :	0001000101 :
00011011010100001100001101000100	11100100101011110011110010111011
0001000110 :	0001000111 :
01001110000001011001011000010001	10110001111110100110100111101110
0001001000 :	0001001001 :
00100111011011001111111101111000	11011000100100110000000010000111
0001001010 :	0001001011 :
01110010001110011010101000101101	10001101110001100101010111010010
0001001100 :	0001001101 :
00010100010111111100110001001011	11101011101000000011001110110100
0001001110 :	0001001111 :
01000001000010101001100100011110	10111110111101010110011011100001
0001010000 :	0001010001 :
00101000100111001111000010001000	11010111011000110000111101110111
0001010010 :	0001010011 :
01111101110010011010010111011101	10000010001101100101101000100010
0001010100 :	0001010101 :
00011011101011111100000111011011	11100100010100000011111000100100
0001010110 :	0001010111 :
01001110111110101001011011101110	10110001000001010110100100010001
0001011000 :	0001011001 :
00100111100100111111111110000111	11011000011011000000000001111000
0001011010 :	0001011011 :

01110010110001101010101011010010	10001101001110010101010100101101
0001011100 :	0001011101 :
00010100101000001100110010110100	11101011010111110011001101001011
0001011110 :	0001011111 :
01000001111101011001100111100001	10111110000010100110011000011110
0001100000 :	0001100001 :
00101000011000110000111110001000	11010111100111001111000001110111
0001100010 :	0001100011 :
01111101001101100101101011011101	10000010110010011010010100100010
0001100100 :	0001100101 :
00011011010100000011110010111011	11100100101011111100001101000100
0001100110 :	0001100111 :
01001110000001010110100111101110	10110001111110101001011000010001
0001101000 :	0001101001 :
00100111011011000000000010000111	11011000100100111111111101111000
0001101010 :	0001101011 :
01110010001110010101010111010010	10001101110001101010101000101101
0001101100 :	0001101101 :
00010100010111110011001110110100	11101011101000001100110001001011
0001101110 :	0001101111 :
01000001000010100110011011100001	10111110111101011001100100011110
0001110000 :	0001110001 :
00101000100111000000111101110111	11010111011000111111000010001000
0001110010 :	0001110011 :
01111101110010010101101000100010	10000010001101101010010111011101
0001110100 :	0001110101 :
00011011101011110011110001000100	11100100010100001100001110111011
0001110110 :	0001110111 :
01001110111110100110100100010001	10110001000001011001011011101110
0001111000 :	0001111001 :
00100111100100110000000001111000	11011000011011001111111110000111
0001111010 :	0001111011 :
01110010110001100101010100101101	10001101001110011010101011010010
0001111100 :	0001111101 :
00010100101000000011001101001011	11101011010111111100110010110100
0001111110 :	0001111111 :

01000001111101010110011000011110	10111110000010101001100111100001
0010000000 :	0010000001 :
00000001110011010110110111000111	11111110001100101001001000111000
0010000010 :	0010000011 :
01010100100110000011100010010010	10101011011001111100011101101101
0010000100 :	0010000101 :
00110010111111100101111011110100	11001101000000011010000100001011
0010000110 :	0010000111 :
01100111101010110000101110100001	10011000010101001111010001011110
0010001000 :	0010001001 :
00001110110000100110001011001000	11110001001111011001110100110111
0010001010 :	0010001011 :
01011011100101110011011110011101	10100100011010001100100001100010
0010001100 :	0010001101 :
00111101111100010101000111111011	11000010000011101010111000000100
0010001110 :	0010001111 :
01101000101001000000010010101110	10010111010110111111101101010001
0010010000 :	0010010001 :
00000001001100100110110100111000	11111110110011011001001011000111
0010010010 :	0010010011 :
01010100011001110011100001101101	10101011100110001100011110010010
0010010100 :	0010010101 :
00110010000000010101111000001011	11001101111111101010000111110100
0010010110 :	0010010111 :
01100111010101000000101101011110	10011000101010111111010010100001
0010011000 :	0010011001 :
00001110001111010110001000110111	11110001110000101001110111001000
0010011010 :	0010011011 :
01011011011010000011011101100010	10100100100101111100100010011101
0010011100 :	0010011101 :
00111101000011100101000100000100	11000010111100011010111011111011
0010011110 :	0010011111 :
01101000010110110000010001010001	10010111101001001111101110101110
0010100000 :	0010100001 :
00000001110011011001001000111000	11111110001100100110110111000111
0010100010 :	0010100011 :

01010100100110001100011101101101	10101011011001110011100010010010
0010100100 :	0010100101 :
00110010111111101010000100001011	11001101000000010101111011110100
0010100110 :	0010100111 :
01100111101010111111010001011110	10011000010101000000101110100001
0010101000 :	0010101001 :
00001110110000101001110100110111	11110001001111010110001011001000
0010101010 :	0010101011 :
01011011100101111100100001100010	10100100011010000011011110011101
0010101100 :	0010101101 :
00111101111110001101011100000100	11000010000001110010100011111011
0010101110 :	0010101111 :
01101000101001001111101101010001	10010111010110110000010010101110
0010110000 :	0010110001 :
00000001001100101001001011000111	11111110110011010110110100111000
0010110010 :	0010110011 :
01010100011001111100011110010010	10101011100110000011100001101101
0010110100 :	0010110101 :
00110010000000011010000111110100	11001101111111100101111000001011
0010110110 :	0010110111 :
01100111010101001111010010100001	10011000101010110000101101011110
0010111000 :	0010111001 :
00001110001111011001110111001000	11110001110000100110001000110111
0010111010 :	0010111011 :
01011011011010001100100010011101	10100100100101110011011101100010
0010111100 :	0010111101 :
00111101000011101010111011111011	11000010111100010101000100000100
0010111110 :	0010111111 :
01101000010110111111101110101110	10010111101001000000010001010001
0011000000 :	0011000001 :
00101001101011101001110110110000	11010110010100010110001001001111
0011000010 :	0011000011 :
01111100111110111100100011100101	10000011000001000011011100011010
0011000100 :	0011000101 :
00011010100111011010111010000011	11100101011000100101000101111100
0011000110 :	0011000111 :

01001111110010001111101111010110	10110000001101110000010000101001
0011001000 : 00100110101000011001001010111111	

(Table 1b)

0011001001 : 11011001010111100110110101000000	0011001010 : 01110011111101001100011111101010
0011001011 : 10001100000010110011100000010101	0011001100 : 00010101100100101010000110001100
0011001101 : 11101010011011010101111001110011	0011001110 : 01000000110001111111010011011001
0011001111 : 10111111001110000000101100100110	0011010000 : 00101001010100011001110101001111
0011010001 : 11010110101011100110001010110000	0011010010 : 01111100000001001100100000011010
0011010011 : 10000011111110110011011111100101	0011010100 : 00011010011000101010111001111100
0011010101 : 11100101100111010101000110000011	0011010110 : 01001111001101111111101100101001
0011010111 : 10110000110010000000010011010110	0011011000 : 00100110010111101001001001000000
0011011001 : 11011001101000010110110110111111	0011011010 : 01110011000010111100011100010101
0011011011 : 10001100111101000011100011101010	0011011100 : 00010101011011011010000101110011
0011011101 : 11101010100100100101111010001100	0011011110 : 01000000001110001111010000100110
0011011111 : 10111111110001110000101111011001	0011100000 : 00101001101011100110001001001111
0011100001 : 11010110010100011001110110110000	0011100010 : 01111100111110110011011100011010
0011100011 : 10000011000001001100100011100101	0011100100 : 00011010100111010101000101111100
0011100101 : 11100101011000101010111010000011	0011100110 : 01001111110010000000010000101001

0011100111 :	0011101000 :
10110000001101111111101111010110	00100110101000010110110101000000
0011101001 :	0011101010 :
11011001010111101001001010111111	01110011111101000011100000010101
0011101011 :	0011101100 :
10001100000010111100011111101010	00010101100100100101111001110011
0011101101 :	0011101110 :
11101010011011011010000110001100	01000000110001110000101100100110
0011101111 :	0011110000 :
10111111001110001111010011011001	00101001010100010110001010110000
0011110001 :	0011110010 :
11010110101011101001110101001111	01111100000001000011011111100101
0011110011 :	0011110100 :
10000011111110111100100000011010	00011010011000100101000110000011
0011110101 :	0011110110 :
11100101100111011010111001111100	01001111001101110000010011010110
0011110111 :	0011111000 :
10110000110010001111101100101001	00100110010111100110110110111111
0011111001 :	0011111010 :
11011001101000011001001001000000	01110011000010110011100011101010
0011111011 :	0011111100 :
10001100111101001100011100010101	00010101011011010101111010001100
0011111101 :	0011111110 :
11101010100100101010000101110011	01000000001110000000101111011001
0011111111 :	0100000000 :
10111111110001111111010000100110	00001010111110010001101100101011
0100000001 :	0100000010 :
11110101000001101110010011010100	01011111101011000100111001111110
0100000011 :	0100000100 :
10100000010100111011000110000001	00111001110010100010100000011000
0100000101 :	0100000110 :
11000110001101011101011111100111	01101100100111110111110101001101
0100000111 :	0100001000 :
10010011011000001000001010110010	00000101111101100001010000100100
0100001001 :	0100001010 :
11111010000010011110101111011011	01010000101000110100000101110001

0100001011 :	0100001100 :
10101111010111001011111010001110	00110110110001010010011100010111
0100001101 :	0100001110 :
11001001001110101101100011101000	01100011100100000111001001000010
0100001111 :	0100010000 :
10011100011011111000110110111101	00001010000001100001101111010100
0100010001 :	0100010010 :
11110101111110011110010000101011	01011111010100110100111010000001
0100010011 :	0100010100 :
10100000101011001011000101111110	00111001001101010010100011100111
0100010101 :	0100010110 :
11000110110010101101011100011000	01101100011000000111110110110010
0100010111 :	0100011000 :
10010011100111111000001001001101	00000101000010010001010011011011
0100011001 :	0100011010 :
11111010111101101110101100100100	01010000010111000100000110001110
0100011011 :	0100011100 :
10101111101000111011111001110001	00110110001110100010011111101000
0100011101 :	0100011110 :
11001001110001011101100000010111	01100011011011110111001010111101
0100011111 :	0100100000 :
10011100100100001000110101000010	00001010111110011110010011010100
0100100001 :	0100100010 :
11110101000001100001101100101011	01011111101011001011000110000001
0100100011 :	0100100100 :
10100000010100110100111001111110	00111001110010101101011111100111
0100100101 :	0100100110 :
11000110001101010010100000011000	01101100100111111000001010110010
0100100111 :	0100101000 :
10010011011000000111110101001101	00000101111101101110101111011011
0100101001 :	0100101010 :
11111010000010010001010000100100	01010000101000111011111010001110
0100101011 :	0100101100 :
10101111010111000100000101110001	00110110110001011101100011101000
0100101101 :	0100101110 :
11001001001110100010011100010111	01100011100100001000110110111101

0100101111 :	0100110000 :
10011100011011110111001001000010	00001010000001101110010000101011
0100110001 :	0100110010 :
11110101111110010001101111010100	01011111010100111011000101111110
0100110011 :	0100110100 :
10100000101011000100111010000001	00111001001101011101011100011000
0100110101 :	0100110110 :
11000110110010100010100011100111	01101100011000001000001001001101
0100110111 :	0100111000 :
10010011100111110111110110110010	00000101000010011110101100100100
0100111001 :	0100111010 :
11111010111101100001010011011011	01010000010111001011111001110001
0100111011 :	0100111100 :
10101111101000110100000110001110	00110110001110101101100000010111
0100111101 :	0100111110 :
11001001110001010010011111101000	01100011011011111100011010100010
0100111111 :	0101000000 :
10011100100100000111001010111101	00100010100110101110101101011100
0101000001 :	0101000010 :
11011101011001010001010010100011	01110111110011111011111000001001
0101000011 :	0101000100 :
10001000001100000100000111110110	00010001101010011101100001101111
0101000101 :	0101000110 :
11101110010101100010011110010000	01000100111111001000110100111010
0101000111 :	0101001000 :
10111011000000110111001011000101	00101101100101011110010001010011
0101001001 :	0101001010 :
11010010011010100001101110101100	01111000110000001011000100000110
0101001011 :	0101001100 :
10000111001111110100111011111001	00011110101001101101011101100000
0101001101 :	0101001110 :
11100001010110010010100010011111	01001011111100111000001000110101
0101001111 :	0101010000 :
10110100000011000111110111001010	00100010011001011110101110100011
0101010001 :	0101010010 :
11011101100110100001010001011100	01110111001100001011111011110110

0101010011 :	0101010100 :
10001000110011110100000100001001	00010001010101101101100010010000
0101010101 :	0101010110 :
11101110101010010010011101101111	01000100000000111000110111000101
0101010111 :	0101011000 :
10111011111111000111001000111010	00101101011010101110010010101100
0101011001 :	0101011010 :
11010010100101010001101101010011	01111000001111110110001111111001
0101011011 :	0101011100 :
10000111110000000100111000000110	00011110010110011101011110011111
0101011101 :	0101011110 :
11100001101001100010100001100000	010010110000110010000001011001010
0101011111 :	0101100000 :
10110100111100110111110100110101	00100010100110100001010010100011
0101100001 :	0101100010 :
11011101011001011110101101011100	01110111110011110100000111110110
0101100011 :	0101100100 :
10001000001100001011111000001001	00010001101010010010011110010000
0101100101 :	0101100110 :
11101110010101101101100001101111	01000100111111000111001011000101
0101100111 :	0101101000 :
10111011000000111000110100111010	00101101100101010001101110101100
0101101001 :	0101101010 :
11010010011010101110010001010011	01111000110000000100111011111001
0101101011 :	0101101100 :
10000111001111111011000100000110	00011110101001100010100010011111
0101101101 :	0101101110 :
11100001010110011101011101100000	01001011111100110111110111001010
0101101111 :	0101110000 :
10110100000011001000001000110101	00100010011001010001010001011100
0101110001 :	0101110010 :
11011101100110101110101110100011	01110111001100000100000100001001
0101110011 :	0101110100 :
10001000110011111011111011110110	00010001010101100010011101101111
0101110101 :	0101110110 :
11101110101010011101100010010000	01000100000000110111001000111010

0101110111 : 10111011111111001000110111000101	0101111000 : 00101101011010100001101101010011
0101111001 : 11010010100101011110010010101100	0101111010 : 01111000001111110100111000000110
0101111011 : 10000111110000000101100011111001	0101111100 : 00011110010110010010100001100000
0101111101 : 11100001101001101101011110011111	0101111110 : 01001011000011000111110100110101
0101111111 : 10110100111100111000001011001010	0110000000 : 00001011001101000111011011101100
0110000001 : 11110100110010111000100100010011	0110000010 : 01011110011000010010001110111001
0110000011 : 10100001100111101101110001000110	0110000100 : 00111000000001110100010111011111
0110000101 : 11000111111110001011101000100000	0110000110 : 01101101010100100001000010001010
0110000111 : 10010010101011011110111101110101	0110001000 : 00000100001110110111100111100011
0110001001 : 11111011110001001000011000011100	0110001010 : 01010001011011100010110010110110
0110001011 : 10101110100100011101001101001001	0110001100 : 00110111000010000100101011010000
0110001101 : 11001000111101111011010100101111	0110001110 : 01100010010111010001111110000101
0110001111 : 10011101101000101110000001111010	0110010000 : 00001011110010110111011000010011
0110010001 : 11110100001101001000100111101100	

(Table 1c)

0110010010 : 01011110100111100010001101000110	0110010011 : 10100001011000011101110010111001
0110010100 : 00111000111110000100010100100000	0110010101 : 11000111000001111011101011011111
0110010110 :	0110010111 :

01101101101011010001000001110101	10010010010100101110111110001010
0110011000 :	0110011001 :
00000100110001000111100100011100	11111011001110111000011011100011
0110011010 :	0110011011 :
01010001100100010010110001001001	10101110011011101101001110110110
0110011100 :	0110011101 :
00110111111101110100101000101111	11001000000010001011010111010000
0110011110 :	0110011111 :
01100010101000100001111101111010	10011101010111011110000010000101
0110100000 :	0110100001 :
00001011001101001000100100010011	11110100110010110111011011101100
0110100010 :	0110100011 :
01011110011000011101110001000110	10100001100111100010001110111001
0110100100 :	0110100101 :
00111000000001111011101000100000	11000111111110000100010111011111
0110100110 :	0110100111 :
01101101010100101110111101110101	10010010101011010001000010001010
0110101000 :	0110101001 :
00000100001110111000011000011100	11111011110001000111100111100011
0110101010 :	0110101011 :
01010001011011101101001101001001	10101110100100010010110010110110
0110101100 :	0110101101 :
00110111000010001011010100101111	11001000111101110100101011010000
0110101110 :	0110101111 :
01100010010111011110000001111010	10011101101000100001111110000101
0110110000 :	0110110001 :
00001011110010111000100111101100	11110100001101000111011000010011
0110110010 :	0110110011 :
01011110100111101101110010111001	10100001011000010010001101000110
0110110100 :	0110110101 :
00111000111110001011101011011111	11000111000001110100010100100000
0110110110 :	0110110111 :
01101101101011011110111110001010	10010010010100100001000001110101
0110111000 :	0110111001 :
00000100110001001000011011100011	11111011001110110111100100011100
0110111010 :	0110111011 :

01010001100100011101001110110110	10101110011011100010110001001001
0110111100 :	0110111101 :
00110111111011110110101111010000	11001000000010000100101000101111
0110111110 :	0110111111 :
01100010101000101110000010000101	10011101010111010001111101111010
0111000000 :	0111000001 :
00100011010101111000011010011011	11011100101010000111100101100100
0111000010 :	0111000011 :
01110110000000101101001111001110	10001001111111010010110000110001
0111000100 :	0111000101 :
00010000011001001011010110101000	11101111100110110100101001010111
0111000110 :	0111000111 :
01000101001100011110000011111101	10111010110011100001111100000010
0111001000 :	0111001001 :
00101100010110001000100110010100	11010011101001110111011001101011
0111001010 :	0111001011 :
01111001000011011101110011000001	10000110111100100010001100111110
0111001100 :	0111001101 :
00011111011010111011101010100111	11100000100101000100010101011000
0111001110 :	0111001111 :
01001010001111101110111111110010	10110101110000010001000000001101
0111010000 :	0111010001 :
00100011101010001000011001100100	11011100010101110111100110011011
0111010010 :	0111010011 :
01110110111111011101001100110001	10001001000000100010110011001110
0111010100 :	0111010101 :
00010000100110111011010101010111	11101111011001000100101010101000
0111010110 :	0111010111 :
01000101110011101110000000000010	10111010001100010001111111111101
0111011000 :	0111011001 :
00101100101001111000100101101011	11010011010110000111011010010100
0111011010 :	0111011011 :
01111001111100101101110000111110	10000110000011010010001111000001
0111011100 :	0111011101 :
00011111100101001011101001011000	11100000011010110100010110100111
0111011110 :	0111011111 :

01001010110000011110111100001101	10110101001111100001000011110010
0111100000 :	0111100001 :
00100011010101110111100101100100	11011100101010001000011010011011
0111100010 :	0111100011 :
01110110000000100010110000110001	10001001111111011101001111001110
0111100100 :	0111100101 :
00010000011001000100101001010111	11101111100110111011010110101000
0111100110 :	0111100111 :
01000101001100010001111100000010	10111010110011101110000011111101
0111101000 :	0111101001 :
00101100010110000011101100110101 1	11010011101001111000100110010100
0111101010 :	0111101011 :
01111001000011010010001100111110	10000110111100101101110011000001
0111101100 :	0111101101 :
00011111011010110100010101011000	11100000100101001011101010100111
0111101110 :	0111101111 :
01001010001111100001000000001101	10110101110000011110111111110010
0111110000 :	0111110001 :
00100011101010000011110011001101 1	11011100010101111000011001100100
0111110010 :	0111110011 :
01110110111111010010110011001110	10001001000000101101001100110001
0111110100 :	0111110101 :
00010000100110110100101010101000	11101111011001001011010101010111
0111110110 :	0111110111 :
01000101110011100001111111111101	10111010001100011110000000000010
0111111000 :	0111111001 :
00101100101001110111011010010100	11010011010110001000100101101011
0111111010 :	0111111011 :
01111001111100100010001111000001	10000110000011011101110000111110
0111111100 :	0111111101 :
00011111100101000100010110100111	11100000011010111011101001011000
0111111110 :	0111111111 :
01001010110000010001000011110010	10110101001111101110111100001101
1000000000 :	1000000001 :
00011100001101110010111101010001	11100011110010001101000010101110
1000000010 :	1000000011 :

01001001011000100111101000000100	10110110100111011000010111111011
1000000100 :	1000000101 :
00101111000001000001110001100010	11010000111110111110001110011101
1000000110 :	1000000111 :
01111010010100010100100100110111	10000101101011101011011011001000
1000001000 :	1000001001 :
00010011001110000010000001011110	11101100110001111101111110100001
1000001010 :	1000001011 :
01000110011011010111010100001011	10111001100100101000101011110100
1000001100 :	1000001101 :
00100000000010110001001101101101	11011111111101001110110010010010
1000001110 :	1000001111 :
01110101010111100100011000111000	10001010101000011011100111000111
1000010000 :	1000010001 :
00011100110010000010111110101110	11100011001101111101000001010001
1000010010 :	1000010011 :
01001001100111010111101011111011	10110110011000101000010100000100
1000010100 :	1000010101 :
00101111111110110001110010011101	11010000000001001110001101100010
1000010110 :	1000010111 :
01111010101011100100100111001000	10000101010100011011011000110111
1000011000 :	1000011001 :
00010011110001110010000010100001	11101100001110001101111101011110
1000011010 :	1000011011 :
01000110100100100111010111110100	10111001011011011000101000001011
1000011100 :	1000011101 :
00100000111101000001001110010010	11011111000010111110110001101101
1000011110 :	1000011111 :
01110101101000010100011011000111	10001010010111101011100100111000
1000100000 :	1000100001 :
00011100001101111101000010101110	11100011110010000010111101010001
1000100010 :	1000100011 :
01001001011000101000010111111011	10110110100111010111101000000100
1000100100 :	1000100101 :
00101111000001001110001110011101	11010000111110110001110001100010
1000100110 :	1000100111 :

01111010010100011011011011001000	10000101101011100100100100110111
1000101000 :	1000101001 :
00010011001110001101111110100001	11101100110001110010000001011110
1000101010 :	1000101011 :
01000110011011011000101011110100	10111001100100100111010100001011
1000101100 :	1000101101 :
00100000000010111110110010010010	11011111111101000001001101101101
1000101110 :	1000101111 :
01110101010111101011100111000111	10001010101000010100011000111000
1000110000 :	1000110001 :
00011100110010001101000001010001	11100011001101110010111110101110
1000110010 :	1000110011 :
01001001100111011000010100000100	10110110011000100111101011111011
1000110100 :	1000110101 :
00101111111110111110001101100010	110100000000010000001110010011101
1000110110 :	1000110111 :
01111010101011101011011000110111	10000101010100010100100111001000
1000111000 :	1000111001 :
00010011110001111101111101011110	11101100001110000010000010100001
1000111010 :	1000111011 :
01000110100100101000101000001011	10111001011011010111010111110100
1000111100 :	1000111101 :
00100000111101001110110001101101	11011111000010110001001110010010
1000111110 :	1000111111 :
01110101101000011011100100111000	10001010010111100100011011000111
1001000000 :	1001000001 :
00110100010101001101111100100110	11001011101010110010000011011001
1001000010 :	1001000011 :
01100001000000011000101001110011	10011110111111100111010110001100
1001000100 :	1001000101 :
00000111011001111110110000010101	111110001001100000001001111101010
1001000110 :	1001000111 :
01010010001100101011100101000000	10101101110011010100011010111111
1001001000 :	1001001001 :
00111011010110111101000000101001	11000100101001000010111111010110
1001001010 :	1001001011 :

01101110000001110100001010111100	10010001111100010111101010000011
1001001100 :	1001001101 :
00001000011010001110001100011010	11110111100101110001110011100101
1001001110 :	1001001111 :
01011101001111011011011001001111	10100010110000100100100110110000
1001010000 :	1001010001 :
00110100101010111101111111011001	11001011010101000010000000100110
1001010010 :	1001010011 :
01100001111111101000101010001100	10011110000000010111010101110011
1001010100 :	1001010101 :
00000111100110001110110011101010	11111000011001110001001100010101
1001010110 :	1001010111 :
01010010110011011011100110111111	10101101001100100100011001000000
1001011000 :	1001011001 :
00111011101001001101000011010110	11000100010110110010111100101001
1001011010 :	
01101110111100011000010110000011	

(Table 1d)

1001011011 :	1001011100 :
10010001000011100111101001111100	00001000100101111111000111100101
1001011101 :	1001011110 :
11110111011010000001110000011010	01011101110000101011011010110000
1001011111 :	1001100000 :
10100010001111010100100101001111	01101000101010000100000011011001
1001100001 :	1001100010 :
11001011101010111101111100100110	11000010000000101110101100011100
1001100011 :	1001100100 :
10011110111111101000101001110011	00000111011001110001001111101010
1001100101 :	1001100110 :
11110001001100011101100000010101	01010010001100100100011010111111
1001100111 :	1001101000 :
10101101110011011011100101000000	00111011010110110010111111010110
1001101001 :	1001101010 :
10001001010010011010000000101001	01101110000001110011110101000011

1001101011 : 10010001111100011000010101111100	1001101100 : 00010000110100000011100111001 01
1001101101 : 11110111100101111110001100011010	1001101110 : 01011101001111010100100110110000
1001101111 : 10100010110000101011011001001111	1001110000 : 01101001010101100100000000100110
1001110001 : 11001011010101001101111111011001	1001110010 : 01100001111111100111010101110011
1001110011 :10011110000000011000101 010001100	1001110100 : 00001111001100000010011000101 01
1001110101 : 11111000011001111110110011101010	1001110110 : 10100101100110101000110010000 00
1001110111 : 10101101001100101011100110111111	1001111000 : 00111011101001000010111100101001
1001111001 : 11000100010110111101000011010110	1001111010 : 01101110111100010111101001111100
1001111011 : 00100010000111010000101100000 11	1001111100 : 00001000100101110001110000011010
1001111101 : 11110111011010001110001111100101	1001111110 : 01011101110000100100100101001111
1001111111 : 10100010001111011011011010110000	1010000000 : 00011101111110100100001010010110
1010000001 : 11000100000010110111101011 01001	1010000010 : 01001000101011110001011111000011
1010000011 : 01101110101000011101000000111100	1010000100 : 01011101100100101110001101001 01
1010000101 : 10100010011011010001110010110 10	1010000110 : 01111011100111000010010011110000
1010000111 : 10000100011000111101101100001111	1010001000 : 00100101111010101001101100110 01
1010001001 : 11011010000101010110010011001 10	1010001010 : 10001111010000000011000110011 00
1010001011 : 10111000010111111110011100110011	1010001100 : 00100001110001100111111010101010
1010001101 : 10111100011100110000001010101 01	1010001110 : 01110100100100110010101111111111

1010001111 : 00010110110110011010100000000000	1010010000 : 0011101000001010100001001101001
1010010001 : 11100010111110101011110110010110	1010010010 : 1001000010100000001011100111100
1010010011 : 10110111101011111110100011000011	1010010100 : 0101110001101100111000101011010
1010010101 : 1010001110010011000111010100101	1010010110 : 01111011011000110010010000001111
1010010111 : 10000100100111001101101111110000	1010011000 : 0010010000010100100110101100110
1010011001 : 11101101111101011011001010011001	1010011010 : 01000111010111110001100000110011
1010011011 : 10111000101000001110011111001100	1010011100 : 00100001001110010111111001010101
1010011101 : 1011110110001101000000110101010	1010011110 : 01110100011011000010101100000000
1010011111 : 10001011100100111101010011111111	1010100000 : 00011101111110101011110101101001
1010100001 : 1100010000001010100001010010110	1010100010 : 01001000101011111110100000111100
1010100011 : 0110111010100000001011111000011	1010100100 : 0101110110010011000111001011010
1010100101 : 1010001001101100111000110100101	1010100110 : 01111011100111001101101100001111
1010100111 : 0000100011000110010010011110000	1010101000 : 0010010111101011011001001100110
1010101001 : 1101101000010100100110110011001	1010101010 : 01000111101000001110011100110011
1010101011 : 01110000101111110001100011001100	1010101100 : 0100001110001101000000101010101
1010101101 : 11011110001110010111111010101010	1010101110 : 1110100100100111101010000000000
1010101111 : 10001011011011000010101111111111	1010110000 : 00011101000001011011110110010110
1010110001 : 1100010111110100100001001101001	1010110010 : 1001000010100001110100011000011

1010110011 :	1010110100 :
10110111101011110001011100111100	01011100011011010001110101001 01
1010110101 :	1010110110 :
10100011100100101110001010110 10	01111011011000111101101111110000
1010110111 :	1010111000 :
00001001001110000100100000011 11	00100100000101010110010100110 01
1010111001 :	1010111010 :
11101101111101010100110101100110	01000111010111111110011111001100
1010111011 :	1010111100 :
01110001010000000011000001100 11	01000010011100110000001101010 10
1010111101 :	1010111110 :
11011110110001100111111001010101	01110100011011001101010011111111
1010111111 :	1011000000 :
00010111001001100101011000000000	00110101100110011011001011100001
1011000001 :	1011000010 :
10010100110011001001101000111 10	01100000110011001110011110110100
1011000011 :	1011000100 :
00111110011001100011000010010 11	00001101010101010000000111010010
1011000101 :	1011000110 :
11111001010101010111111000101101	01010011111111111010100100001 11
1011000111 :	1011001000 :
01011000000000000101011011110 00	00111010100101101011110111101110
1011001001 :	1011001010 :
10001010110100101000010000100 01	01101111110000111110100010111011
1011001011 :	1011001100 :
00100000011110000010111010001 00	00001001101001011000111011011101
1011001101 :	1011001110 :
11101100101101001110001001000 10	01011100111100001101101110001000
1011001111 :	1011010000 :
10100011000011110010010001110111	00110101011001101011001000011110
1011010001 :	1011010010 :
10010101001100101001101111000 01	01100000001100111110011101001011
1011010011 :	1011010100 :
10011111110011000001100010110100	00001100101010110000000100101101
1011010101 :	1011010110 :
11111001101010100111111011010010	10100110000000011010100011110 00

1011010111 :	1011011000 :
10101100111111110010101110000111	00111010011010011011110100010001
1011011001 :	1011011010 :
10001011001011001000010111101110	01101111001111001110100001000100
1011011011 :	1011011100 :
10010000110000110001011110111011	00010010101101010001110001000010
1011011101 :	1011011110 :
11110110101001010111000111011101	01011100000011111101101101110111
1011011111 :	1011100000 :
10100011111100000010010010001000	00110101100110010100110100011110
1011100001 :	1011100010 :
11001010011001101011001011100001	01100000110011000001100001001011
1011100011 :	1011100100 :
10011111001100111110011110110100	00000110101010100111111000101101
1011100101 :	1011100110 :
11111001010101011000000111010010	01010011111111110010101101111000
1011100111 :	1011101000 :
10101100000000001101010010000111	00111010100101100100001000010001
1011101001 :	1011101010 :
11000101011010011011110111101110	01101111110000110001011101000100
1011101011 :	1011101100 :
10010000001111001110100010111011	00001001101001010111000100100010
1011101101 :	1011101110 :
11110110010110101000111011011101	01011100111100000010010001110111
1011101111 :	1011110000 :
10100011000011111101101110001000	00110101011001100100110111100001
1011110001 :	1011110010 :
11001010100110011011001000011110	01100000001100110001100010110100
1011110011 :	1011110100 :
10011111110011001110011101001011	00000110010101010111111011010010
1011110101 :	1011110110 :
11111001101010101000000100101101	01010011000000000010101110000111
1011110111 :	1011111000 :
10101100111111111010100011111000	00111010011010010100001011101110
1011111001 :	1011111010 :
11000101100101101011110100010001	01101111001111000000101111011011

1011111011 :	1011111100 :
10010000110000111110100001000100	00001001010110100111000111011101
1011111101 :	1011111110 :
11110110101001011000111000100010	01011100000011110010010010001000
1011111111 :	1100000000 :
10100011111100001101101101110111	00010110110011100011010001111010
1100000001 :	1100000010 :
11101001001100011100101110000101	01000011100110110110000100101111
1100000011 :	1100000100 :
10111100011001001001111011010000	00100101111111010000011101001001
1100000101 :	1100000110 :
11011010000000101111100010110110	01110000101010000101001000011100
1100000111 :	1100001000 :
10001111010101111010110111100011	00011001110000010011101101110101
1100001001 :	1100001010 :
11100110001111101100010010001010	01001100100101000110111000100000
1100001011 :	1100001100 :
10110011011010111001000111011111	00101010111100100000100001000110
1100001101 :	1100001110 :
11010101000011011111011110111001	01111111101001110101110100010011
1100001111 :	1100010000 :
10000000010110001010001011101100	00010110001100010011010010000101
1100010001 :	1100010010 :
11101001110011101100101101111010	01000011011001000110000111010000
1100010011 :	1100010100 :
10111100100110111001111000101111	0100101000000100000011110110110
1100010101 :	1100010110 :
11011010111111011111100001001001	01110000010101110101001011100011
1100010111 :	1100011000 :
10001111101010001010110100011100	00011001001111100011101110001010
1100011001 :	1100011010 :
11100110110000011100010001110101	01001100011010110110111011011111
1100011011 :10110011100101001001000	1100011100 :
100100000	0101010000011010000100010111001
1100011101 :	1100011110 :
11010101111100101111011101000110	01111111010110000101110111101100

1100011111 : 10000000101001111010001000010011	1100100000 : 00010110110011101100101110000101
1100100001 : 11101001001100010011010001111010	1100100010 : 01000011100110111001111011010000
1100100011 : 10111100011001000110000100101111	

(Table 1e)

1100100100: 00100101111111011111100010110110	1100100101: 11011010000000100000011101001001
1100100110: 01110000101010001010110111100011	1100100111: 10001111010101110101001000011100
1100101000: 00011001110000011100010010001010	1100101001: 11100110001111100011101101110101
1100101010: 01001100100101001001000111011111	1100101011: 10110011011010110110111000100000
1100101100: 00101010111100101111011110111001	1100101101: 11010101000011010000100001000110
1100101110: 01111111101001111010001011101100	1100101111: 10000000010110000101110100010011
1100110000: 000101100011000111001101101111010	1100110001: 11101001110011100011010010000101
1100110010: 01000011011001001001111000101111	1100110011: 10111100100110110110000111010000
1100110100: 00100101000000101111100001001001	1100110101: 11011010111111010000011110110110
1100110110: 011100000010101111010110100011100	1100110111: 100011111101010000101001011100011
1100111000: 00011001001111101100010001110101	1100111001: 11100110110000010011101110001010
1100111010: 01001100011010111001000100100000	1100111011: 10110011100101000110111011011111
1100111100: 00101010000011011111011101000110	1100111101: 11010101111100100000100010111001
1100111110:	1100111111:

01111111010110001010001000010011	10000000101001110101110111101100
1101000000:	1101000001:
00111110101011011100010000001101	11000001010100100011101111110010
1101000010:	1101000011:
01101011111110001001000101011000	10010100000001110110111010100111
1101000100:	1101000101:
00001101100111101111011100111110	11110010011000010000100011000001
1101000110:	1101000111:
01011000110010111010001001101011	10100111001101000101110110010100
1101001000:	1101001001:
00110001101000101100101100000010	11001110010111010011010011111101
1101001010:	1101001011:
01100100111101111001111001010111	10011011000010000110000110101000
1101001100:	1101001101:
00000010100100011111100000110001	11111101011011100000011111001110
1101001110:	1101001111:
01010111110001001010110101100100	10101000001110110101001010011011
1101010000:	1101010001:
00111110010100101100010011110010	11000001101011010011101100001101
1101010010:	1101010011:
01101011000001111001000110100111	10010100111110000110111001011000
1101010100:	1101010101:
00001101011000011111011111000001	11110010100111100000100000111110
1101010110:	1101010111:
01011000001101001010001010010100	10100111110010110101110101101011
1101011000:	1101011001:
00110001010111011100101111111101	11001110101000100011010000000010
1101011010:	1101011011:
01100100000010001001111010101000	10011011111101110110000101010111
1101011100:	1101011101:
00000010011011101111100011001110	11111101100100010000011100110001
1101011110:	1101011111:
01010111001110111010110110011011	10101000110001000101001001100100
1101100000:	1101100001:
00111110101011010011101111110010	11000001010100101100010000001101
1101100010:	1101100011:

01101011111110000110111010100111	10010100000001111001000101011000
1101100100:	1101100101:
00001101100111100000100011000001	11110010011000011111011100111110
1101100110:	1101100111:
01011000110010110101110110010100	10100111001101001010001001101011
1101101000:	1101101001:
00110001101000100011010011111101	11001110010111011100101100000010
1101101010:	1101101011:
01100100111101110110000110101000	10011011000010001001111001010111
1101101100:	1101101101:
00000010100100010000011111001110	111111010110111011111000000110001
1101101110:	1101101111:
01010111110001000101001010011011	10101000001110111010110101100100
1101110000:	1101110001:
00111110010100100011101100001101	11000001101011011100010011110010
1101110010:	1101110011:
01101011000001110110111001011000	10010100111110001001000110100111
1101110100:	1101110101:
00001101011000010000100000111110	11110010100111101111011111000001
1101110110:	1101110111:
01011000001101000101110101101011	10100111110010111010001010010100
1101111000:	1101111001:
00110001010111010011010000000010	11001110101000101100101111111101
1101111010:	1101111011:
01100100000001000011000010101011 1	10011011111101111001111010101000
1101111100:	1101111101:
00000010011011100000011100110001	11111101100100011111100011001110
1101111110:	1101111111:
01010111001110110101001001100100	10101000110001001010110110011011
1110000000:	1110000001:
00010111000000110101100110111101	11101000111111001010011001000010
1110000010:	1110000011:
01000010010101100000110011101000	10111101101010011111001100010111
1110000100:	1110000101:
00100100001100000110101010001110	11011011110011111001010101110001
1110000110:	1110000111:

01110001011001010011111111011011	10001110100110101100000000100100
1110001000:	1110001001:
00011000000011000101011010110010	11100111111100111010100101001101
1110001010:	1110001011:
01001101010110010000001111100111	10110010101001101111110000011000
1110001100:	1110001101:
00101011001111110110010110000001	1101010011000000100110100111110
1110001110:	1110001111:
01111110011010100011000011010100	10000001100101011100111100101011
1110010000:	1110010001:
0001011111111000101100101000010	1110100000000111010011010111101
1110010010:	1110010011:
01000010101010010000110000010111	10111101010101101111001111101000
1110010100:	1110010101:
00100100110011110110101001110001	11011011001100001001010110001110
1110010110:	1110010111:
01110001100110100011111100100100	10001110011001011100000011011011
1110011000:	1110011001:
00011000111001101010110010011101	11100111000011001010100110110010
1110011010:	1110011011:
01001101101001100000001100011000	10110010010110011111110011100111
1110011100:	1110011101:
00101011110000000110010101111110	11010100001111111001101010000001
1110011110:	1110011111:
01111110100101010011000000101011	10000001011010101100111111010100
1110100000:	1110100001:
00010111000000111010011001000010	11101000111111000101100110111101
11101000010:	1110100011:
01000010010101101111001100010111	10111101101010010000110011101000
1110100100:	1110100101:
00100100001100001001010101110001	11011011110011110110101010001110
1110100110:	1110100111:
01110001011001011100000000100100	10001110100110100011111111011011
1110101000:	1110101001:
00011000000011001010100101001101	11100111111100110101011010110010
1110101010:	1110101011:

0100110101011001111111110000011000	10110010101001100000001111100111
1110101100:	1110101101:
00101011001111111001101001111110	11010100110000000110010110000001
1110101110:	1110101111:
01111110011010101100111100101011	10000001100101010011000011010100
1110110000:	1110110001:
00010111111111001010011010111101	11101000000000110101100101000010
1110110010:	1110110011:
01000010101010011111001111101000	10111101010101100000110000010111
1110110100:	1110110101:
00100100110011111001010110001110	11011011001100000110101001110001
1110110110:	1110110111:
01110001100110101100000011011011	10001110011001010011111100100100
1110111000:	1110111001:
00011000111100111010100110110010	11100111000011000101011001001101
1110111010:	1110111011:
01001101101001101111110011100111	10110010010110010000001100011000
1110111100:	1110111101:
00101011110000000100110101000001	11010100001111110110010101111110
1110111110:	1110111111:
01111110100101011100111111010100	10000001011010100011000000101011
1111000000:	1111000001:110000001001111101010110
00111111011000001010100111001010	00110101
1111000010:	1111000011:
01101010001101011111110010011111	10010101110010100000001101100000
1111000100:	1111000101:
00001100010100111001101011111001	11110011101011000110010100000110
1111000110:	1111000111:
01011001000001101100111110101100	10100110111110010011000001010011
1111001000:	1111001001:
00110000011011111010011011000101	11001111100100000101100100111010
1111001010:	1111001011:
01100101001110101111001110010000	10011010110001010000110001101111
1111001100:	1111001101:
00000011010111001001010111110110	11111100101000110110101000001001
1111001110:	1111001111:

01010110000010011100000010100011	10101001111101100001111110101100
1111010000:	1111010001:
00111111100111111010100100110101	11000000011000000101011011001010
1111010010:	1111010011:
01101010110010101111110001100000	10010101001101010000001110011111
1111010100:	1111010101:
00001100101011001001101000000110	11110011010100110110010111111001
1111010110:	1111010111:
01011001111110011100111101010011	10100110000001100011000010101100
1111011000:	1111011001:
00110000100100001010011000111010	11001111011011110101100111000101
1111011010:	1111011011:
01100101110001011111001101101111	10011010001110100000110010010000
1111011100:	1111011101:
00000011101000111001010100001001	11111100010111000110101011110110
1111011110:	1111011111:
010101101111011011000000011100	10101001000010010011111110100011
1111100000:	1111100001:
00111111011000000101011000110101	11000000100111111010100111001010
1111100010:	1111100011:
01101010001101010000001101100000	10010101110010101111110010011111
1111100100:	1111100101:
00001100010100110110010100000110	11110011101011001001101011111001
1111100110:	1111100111:
01011001000001100011000001010011	10100110111111001110011110101100
1111101000:	1111101001:
00110000011011110101100100111010	11001111100100001010011011000101
1111101010:	1111101011:
01100101001110100000110001101111	10011010110001011111001110010000
1111101100:	
00000011010111000110101000001001	

(Table 1f)

1111101101	:
11111100101000111001010111110110	

1111101110	:
01010110000010010011111101011100	
1111101111	:
10101001111101101100000010100011	
1111110000	:
00111111100111110101011011001010	
1111110001	:
11000000011000001010100100110101	
1111110010	:
01101010110010100000001110011111	
1111110011	:
10010101001101011111110001100000	
1111110100	:
00001100101011000110010111111001	
1111110101	:
11110011010100111001101000000110	
1111110110	:
01011001111110010011000010101100	
1111110111	:
10100110000001101100111101010011	
1111111000	:
00110000100100000101100111000101	
1111111001	:
11001111011011111010011000111010	
1111111010	:
01100101110001010000110010010000	
1111111011	:
10011010001110101111001101101111	
1111111100	:
00000011101000110110101011110110	
1111111101	:
11111100010111001001010100001001	
1111111110	:
01010110111101100011111110100011	
1111111111	:
10101001000010011100000001011100	

The decoding apparatus according to the embodiment of the present invention will be described referring to FIG. 9. An input signal r(t) is applied to 15 multipliers 902 to 906 and a correlation calculator 920. The input signal r(t) was encoded with a predetermined Walsh code and a predetermined mask sequence in a transmitter. A mask sequence generator 910 generates all possible 15 mask sequences M1 to M15. The multipliers 902 to 906 multiply the mask sequences received from the mask sequence generator 910 by the input signal r(t). The multiplier 902 multiplies the input signal r(t) by the mask sequence M1 received from the mask sequence generator 910. The multiplier 904 multiplies the input signal r(t) by the mask sequence M2 received from the mask sequence generator 910. The multiplier 906 multiplies the input signal r(t) by the mask sequence M15 received from the mask sequence generator 910. If the transmitter encoded TFCI bits with the predetermined mask sequence, one of the outputs of the multipliers 902 to 906 is free of the mask sequence, which means the mask sequence has no effect on the correlations calculated by one of the correlation calculators. For example, if the transmitter used the mask sequence M2 for encoding the TFCI bits, the output of the multiplier 904 that multiplies the mask sequence M2 by the input signal r(t) is free of the mask sequence. The mask sequence-free signal is TFCI bits encoded with the predetermined Walsh code. Correlation calculators 920 to 926 calculate the correlations of the input signal r(t) and the outputs of the multipliers 902 to 906 to 64 bi-orthogonal codes. The 64 bi-orthogonal codes have been defined before. The correlation calculator 920 calculates the correlation values of the input signal r(t) to the 64 bi-orthogonal codes of length 32, selects the maximum correlation value from the 64 correlations, and outputs the selected correlation value, a bi-orthogonal code index corresponding to the selected correlation value, and its unique index "0000" to a correlation comparator 940.

The correlation calculator 922 calculates the correlation values of the output of the multiplier 902 to the 64 bi-orthogonal codes, selects the maximum value of the 64 correlations, and outputs the selected correlation value, a bi-orthogonal code index corresponding to the selected correlation, and its unique index "0001" to the correlation comparator 940. The correlation calculator 924 calculates the correlation values of the output of the multiplier 904 to the 64 bi-orthogonal codes, selects the maximum of the 64 correlation values, and outputs the selected correlation value, a bi-orthogonal code index corresponding to the selected correlation value, and its unique index "0010" to the correlation comparator 940. Other correlation calculators(not shown) calculate the correlation values of the outputs of the correspondent multipliers to the 64 bi-orthogonal codes and operate similar to the above described correlation calculators, respectively.

Finally, the correlation calculator 926 calculates the correlation values of the output of the multiplier 906 to the 64 bi-orthogonal codes, selects the maximum value of the 64 correlations, and outputs the selected correlation value, a bi-orthogonal code index corresponding to the selected correlation value, and its unique index "1111" to the correlation comparator 940.

The unique indexes of the correlation calculators 920 to 926 are the same as the indexes of the mask sequences multiplied by the input signal r(t) in the multipliers 902 to 906. Table 2 lists the 15 mask indexes multiplied in the multipliers and a mask index assigned to the case that no mask sequence is used, by way of example.

(Table 2)

mask sequence	mask sequence index	mask sequence	mask sequence index
not used	0000	M8	1000
M1	0001	M9	1001
M2	0010	M10	1010
M3	0011	M11	1011
M4	0101	M12	1100
M5	0101	M13	1101
M6	0110	M14	1110
M7	0111	M15	1111

As shown in Table 2, the correlation calculator 922, which receives the signal which is the product of the input signal r(t) and the mask sequence M1, outputs "0001" as its index. The correlation calculator 926, which receives the signal which is the product of the input signal r(t) and the mask sequence M15, outputs "1111" as its index. The correlation calculator 920, which receives only the input signal r(t), outputs "0000" as its index.

Meanwhile, the bi-orthogonal code indexes are expressed in a binary code. For example, if the correlation to $\overline{W4}$ which is the complement of W4is the largest correlation value, a corresponding bi-orthogonal code index (a0 to a9) is "001001".

The correlation comparator 940 compares the 16 maximum correlation values received from the correlation calculators 920 to 926, selects the highest correlation value

from the 16 received maximum correlation values, and outputs TFCI bits based on the bi-orthogonal code index and the mask sequence index(the unique index) received from the correlation calculator that corresponds to the highest correlation value. The TFCI bits can be determined by combining the bi-orthogonal code index and the mask sequence index. For example, if the mask sequence index is that of M4(0100) and the bi-orthogonal code index is that of $\overline{W4}$(001001), the TFCI bits(a9 to a0) are "the M4 index(0100) + the $\overline{W4}$ index(001001)". That is, the TFCI bits(a9 to a0) are "0100001001"

Assuming that the transmitter transmitted code symbols corresponding to TFCI bits (a0 to a9) "1011000010", it can be said that the transmitter encoded the TFCI bits with $\overline{W6}$ and M4 according to the afore-described encoding procedure. The receiver can determine that the input signal r(t) is encoded with the mask sequence M4 by multiplying the input signal r(t) by all the mask sequences and that the input signal r(t) is encoded with $\overline{W6}$ by calculating the correlations of the input signal r(t) to all the bi-orthogonal codes. Based on the above example, the fifth correlation calculator(not shown) will output the largest correlation value, the index of $\overline{W6}$(101100) and its unique index(0010). Then, the receiver outputs the decoded TFCI bits(a0 to a9) "1011000010" by adding the index of $\overline{W6}$ "101100" and the M4 index "0010".

In the embodiment of the decoding apparatus, the input signal r(t) is processed in parallel according to the number of mask sequences. It can be further contemplated that the input signal r(t) is sequentially multiplied by the mask sequences and the correlations of the products are sequentially calculated in another embodiment of the decoding apparatus.

FIG. 17 illustrates another embodiment of the decoding apparatus.

Referring to FIG. 17, a memory 1720 stores an input 32-symbol signal r(t). A mask sequence generator 1710 generates 16 mask sequences that were used in the transmitter and outputs them sequentially. A multiplier 1730 multiplies one of the 16 mask sequences received from the mask sequence generator 1710 by the input signal r(t) received from the memory 1720. A correlation calculator 1740 calculates the output of the multiplier 1730 to 64 biorthogonal codes bi-orthogonalof length 32 and outputs the maximum correlation value and the index of a biorthogonal code corresponding to the largest correlation value to a correlation comparator 1750. The correlation comparator

1750 stores the maximum correlation value and the biorthogonal code index received from the correlation calculator 1740, and the index of the mask sequence received from the mask sequence generator 1710.

Upon completion of above processing with the mask sequence, the memory 1720 outputs the stored input signal r(t) to the multiplier 1730. The multiplier 1730 multiplies the input signal r(t) by one of the other mask sequences. The correlation calculator 1740 calculates correlation of the the output of the multiplier 1730 to the 64 biorthogonal codes of length 32 and outputs the maximum correlation value and the index of a biorthogonal code corresponding to the maximum correlation value. The correlation comparator 1750 stores the maximum correlation value, the biorthogonal code index corresponding to the maximum correlation value, and the mask sequence index received from the mask sequence generator 1710.

The above procedure is performed on all of the 16 mask sequences generated from the mask sequence generator 1710. Then, 16 maximum correlation values the indexes of biorthogonal codes corresponding to the maximum correlation value are stored in the correlation comparator 1750. The correlation comparator 1750 compares the stored 16 correlation values and selects the one with the highest correlation and outputs TFCI bits by combining the indexes of the biorthogonal code and mask sequence index corresponding to the selected maximum correlation value. When the decoding of the TFCI bits is completed, the input signal r(t) is deleted from the memory 1720 and the next input signal r(t+1) is stored.

While the correlation comparator 1750 compares the 16 maximum correlation values at one time in the decoding apparatus of FIG. 17, real-time correlation value comparison can be contemplated. That is, the first input maximum correlation value is compared with the next input maximum correlation value and the larger of the two correlation values and a mask sequence index and a biorthogonal code index corresponding to the correlation are stored. Then, the thirdly input maximum correlation is compared with the stored correlation and the larger of the two correlations and a mask sequence index and a biorthogonal code index corresponding to the selected correlation are stored. This comparision/operation occurs 15 times which is the number of mask sequences generated from the mask sequence generator 1710. Upon completion of all the operations, the correlation comparator 1710output the finally stored biorthogonal index(a0 to a6) and mask sequence index(a7 to a9) and outputs the added bits as TFCI bits.

FIG. 10 is a flowchart illustrating the operation of the correlation comparator 940 shown in FIG. 9. The correlation comparator 940 stores the sixteen maximum correlation values, selects a highest correlation value out of the 16 maximum correlation values and output TFCI bits based on the indexes of a bi-orthogonal code and a mask sequence corresponding to the selected highest correlation value. The sixteen correlation values are compared, and TFCI bits are outputted based on the indexes of a bi-orthogonal code and a mask sequence corresponding to the highest correlation value.

Referring to FIG. 10, a maximum correlation index i is set to 1 and the indices of a maximum correlation value, a biorthogonal code, and a mask sequence to be checked are set to 0s in step 1000. In step 1010, the correlation comparator 940 receives a 1^{st} maximum correlation value, a 1^{st} bi-orthogonal code index, and a 1^{st} mask sequence index from the correlation calculator 920. The correlation comparator 940 compares the 1^{st} maximum correlation with an the previous maximum correlation value in step 1020. If the 1^{st} maximum correlation is greater than the previous maximum correlation, the procedure goes to step 1030. If the 1^{st} maximum correlation is equal to or smaller than the previous maximum correlation, the procedure goes to step 1040. In step 1030, the correlation comparator 940 designates the 1^{st} maximum correlation as a final maximum correlation and stores the 1^{st} bi-orthogonal code and mask sequence indexes as final bi-orthogonal code and mask sequence indexes. In step 1040, the correlation comparator 940 compares the index i with the number 16 of the correlation calculators to determine whether all 16 maximum correlations are completely compared. If i is not 16, the index i is increased by 1 in step 1060 and the procedure returns to step 1010. Then, the above procedure is repeated.

In step 1050, the correlation comparator 940 outputs the indexes of the bi-orthogonal code and the mask sequence that correspond to the final maximum correlation as decoded bits. The bi-orthogonal code index and the mask sequence index corresponding to the decoded bits are those corresponding to the final maximum correlation among the 16 maximum correlation values received from the 16 correlation calculators.

<u>3. Second Embodiment of Encoding/Decoding Apparatus and Method</u>

The (32, 10) TFCI encoder that outputs a 32-symbol TFCI codeword in view of 16 slots has been described in the first embodiment of the present invention. Recently,

the IMT-2000 standard specification dictates having 15 slots in one frame. Therefore, the second embodiment of the present invention is directed to a (30, 10) TFCI encoder that outputs a 30-symbol TFCI codeword in view of 15 slots. Therefore, the second embodiment of the present invention suggests an encoding apparatus and method for outputting 30 code symbols by puncturing two symbols of 32 coded symbols(codeword) as generated from the (32, 10) TFCI encoder.

The encoding apparatuses according to the first and second embodiments of the present invention are the same in configuration except that sequences output from a one-bit generator, a basis Walsh code generator, and a basis mask sequence generator. The encoder apparatus outputs coded symbols of length 30 with symbol #0(1st symbol) and symbol #16(17th symbol) are punctured in the encoding apparatus of the second embodiment.

Referring to FIG. 8, 10 input information bits a0 to a9 are applied to the input of the 840 to 849. The one-bit generator 800 outputs symbols 1s(length 32) to the multiplier 840. The multiplier 840 multiplies the input information bit a0 by each 32 symbol received from the one-bit generator 800. The basis Walsh code generator 810 simultaneously generates basis Walsh codes W1, W2, W4, W8, and W16 of length 32. The multiplier 841 multiplies the input information bit a1 by the basisWalsh code W1 "01010101010101010101010101010101". The multiplier 842 multiplies the input information bit a2 by the basis Walsh code W2 "00110011001100110011001100110011". The multiplier 843 multiplies the input information bit a3 by the basis Walsh code W4 "00001111000011110000111100001111". The multiplier 844 multiplies the input information bit a4 by the basis Walsh code W8 "00000000111111110000000011111111". The multiplier 845 multiplies the input information bit a5 by the basis Walsh code W16 "00000000000000001111111111111111".

The basis mask sequence generator 820 simultaneously generates basis mask sequences M1, M2, M4, and M8 of length 32. The multiplier 846 multiplies the input information bit a6 by the basis mask sequence M1 "00101000011000111111000001110111". The multiplier 847 multiplies the input information bit a7 by the basis mask sequence M2 "00000001110011010110110111000111". The multiplier 848 multiplies the input information bit a8 by the basis mask sequence M4

"00001010111111001000110110010101 1". The multiplier 849 multiplies the input information bit a9 by the basis mask sequence M8 "00011100000110111001011110101000 1". The multipliers 840 to 849 function like switches that control the output of or the generation of the bits from the one-bit generator, each of the basis walsh codes and each of the basis mask sequences.

The adder 860 sums the outputs of the multipliers 840 to 849 symbol by symbol and outputs 32 coded symbols (i.e., a TFCI codeword). Out of the 32 coded symbols, two symbols will be punctured at predetermined positions (i.e. the symbol #0(the first symbol) and symbol #16(the 17^{th} symbol) of the adder 860 output are punctured). The remaining 30 symbols will become the 30 TFCI symbols. It will be easy to modify the second embodiment of present invention. For example, the one-bit generator 800, basis walsh generator 810, basis mask sequence generator 820 can generate 30 symbols which excludes the #0 and #16 symbols. The adder 860 then adds the output of the one-bit generator 800, basis walsh generator 810 and basis mask sequence generator 820 bit by bit and output 30 encoded symbols as TFCI symbols.

FIG. 12 is a encoding method for the second embodiment of present invention. The flowchart illustrating the steps of the encoding apparatus according to the second embodiment of the present invention when the number of slots is 15.

Referring to FIG. 12, 10 input information bits a0 to a9 are received and variables sum and j are set to an initial value 0 in step 1200. In step 1210, it is determined whether j is 30. If j is not 30 in step 1210, the j^{th} symbols W1(j), W2(j), W4(j), W8(j), and W16(j) of the basis Walsh codes W1, W2, W4, W8, and W16 (each having two punctured bits) and the j^{th} symbols M1(j), M2(j), M4(j), and M8(j) of the basis mask sequences M1, M2, M4, and M8 (each having two punctured bits) are received in step 1220. Then, the received symbols are multiplied by the input information bits on a symbol basis and the multiplied symbols are summed in step 1230. In step 1240, sum indicating the achieved j^{th} code symbol is output. j is increased by 1 in step 1250 and then the procedure returns to step 1210. Meanwhile, if j is 30 in step 1210, the encoding procedure ends.

The (30, 10) encoder outputs 1024 codewords equivalent to the codewords of the (32, 10) encoder with symbols #0 and #16 punctured. Therefore, the total number of information can be expressed is 1024.

The output of a (30, 9) encoder is combinations of 32 Walsh codes of length 30 obtained by puncturing symbols #0 and #16 of each of 32 Walsh codes of length 32, 32 bi-orthogonal codes obtained by adding 1 to each symbol of the punctured Walsh codes (by multiplying −1 to each symbol in the case of a real number), and 8 mask sequences obtained by combining any three of the four punctured basis mask sequences.

The output of a (30, 8) encoder is combinations of 32 Walsh codes of length 30 obtained by puncturing #0 and #16 symbols from each of 32 Walsh codes having a length 32 symbols, 32 bi-orthogonal codes obtained by adding 1 to each symbol of the punctured Walsh codes (by multiplying −1 to each symbol in the case of a real number), and 4 mask sequences obtained by combining any two of the four punctured basis mask sequences.

The output of a (30, 7) encoder is combinations of 32 Walsh codes of length 30 obtained by puncturing #0 and #16 symbols from each of 32 Walsh codes having a length 32 symbols, 32 bi-orthogonal codes obtained by adding 1 to each symbol of the punctured Walsh codes (by multiplying −1 to each symbol in the case of a real number), and one of the four punctured basis mask sequences.

All the above encoders for providing an extended TFCI have a minimum distance of 10. The (30, 9), (30, 8), and (30, 7) encoders can be implemented by blocking input and output of at least one of the four basis mask sequences generated from the basis mask sequence generator 820 shown in FIG. 8.

The above encoders flexibly encode TFCI bits according to the number of the TFCI bits and has a maximized minimum distance that determines encoding performance.

A decoding apparatus according to the second embodiment of the present invention is the same in configuration and operation as the decoding apparatus of the first embodiment except for different signal lengths of the encoded symbols. That is, after (32,10) encoding, two symbols out of the 32 encoded symbols are punctured, or basis walsh codes with two punctured symbols and basis mask sequences with two punctured symbols are used for generating the 30 encoded symbols. Therefore, except for the received signal r(t) which includes a signal of 30 encoded symbols and insertion of dummy signals at the punctured positions, all decoding operations are equal to the description of the first embodiment of present invention.

As FIG. 17, this second embodiment of decoding also can be implemented by a single multiplier for multiplying the masks with r(t) and a single correlation calculator for calculating correlation values of bi-orthogonal codes.

4. Third Embodiment of Encoding/Decoding Apparatus and Method

The third embodiment of the present invention provides an encoding apparatus for blocking the output of a one-bit generator in the (30, 7), (30, 8), (30, 9) or (30, 10) (hereinafter we express (30, 7-10))encoder of the second embodiment and generating another mask sequence instead in order to set a minimum distance to 11. The encoders refer to an encoder that outputs a 30-symbol TFCI codeword for the input of 7, 8, 9 or 10 TFCI bits.

FIG. 14 is a block diagram of a third embodiment of the encoding apparatus for encoding a TFCI in the IMT 2000 system. In the drawing, a (30, 7-10) encoder is configured to have a minimum distance of 11.

The encoding apparatus of the third embodiment is similar in structure to that of the second embodiment except that a mask sequence generator 1480 for generating a basis mask sequence M16 and a switch 1470 for switching the mask sequence generator 1480 and a one-bit generator 1400 to a multiplier 1440 are further provided to the encoding apparatus according to the third embodiment of the present invention.

The two bit punctured basis mask sequences M1, M2, M4, M8, and M16 as used in FIG. 14 are

M1 = 000001011111000010110100111110
M2 = 000110001100110001111010110111
M4 = 010111100111101010000001100111
M8 = 011011001000001111011100001111
M16 = 100100011110011111000101010011

Referring to FIG. 14, when a (30, 6) encoder is used, the switch 1470 switches the one-bit generator 1400 to the multiplier 1440 and blocks all the basis mask sequences generated from a basis mask sequence generator 1480. The multiplier 1440 multiplies the symbols from the one-bit generator 1400 with the input information bit a0, symbol by symbol.

If a (30, 7-10) encoder is used, the switch 1470 switches the mask sequence generator 1480 to the multiplier 1440 and selectively uses four basis mask sequences generated from a basis mask sequence generator 1420. In this case, 31 mask sequences M1 to M31 can be generated by combining 5 basis mask sequences.

The structure and operation of outputting code symbols for the input information bits a0 to a9 using multipliers 1440 to 1449 are the same as the first and second embodiments. Therefore, their description will be omitted.

As stated above, the switch 1470 switches the mask sequence generator 1480 to the multiplier 1440 to use the (30, 7-10) encoder, whereas the switch 1470 switches the one-bit generator 1400 to the multiplier 1440 to use the (30, 6) encoder.

For the input of 6 information bits, the (30, 6) encoder outputs a 30-symbol codeword by combining 32 Walsh codes of length 30 with 32 bi-orthogonal codes obtained by inverting the Walsh codes by the use of the one-bit generator 1400.

For the input of 10 information bits, the (30, 10) encoder outputs a 30-symbol codeword by combining 32 Walsh codes of length 30 and 32 mask sequences generated using five basis mask sequences. Here, the five basis mask sequences are M1, M2, M4, M8, and M16, as stated above and the basis mask sequence M16 is output from the mask sequence generator 1480 that is added for the encoding apparatus according to the third embodiment of the present invention. Hence, 1024 codewords can be achieved from the (30, 10) encoder. The (30, 9) encoder outputs a 30-symbol codeword by combining 32 Walsh codes and 16 mask sequences, for the input of 9 information bits. The 16 mask sequences are achieved by combining four of five basis mask sequences. The (30, 8) encoder outputs a 30-symbol codeword by combining 32 Walsh codes and 8 mask sequences, for the input of 8 information bits. The 8 mask sequences are obtained by combining three of five basis mask sequences. For the input of 7 information bits, the (30, 7) encoder outputs a 30-symbol codeword by combining 32 Walsh codes of length 30 and four mask sequences. The four mask sequences are obtained by combining two of five basis mask sequences.

All the above (30, 7-10) encoders have a minimum distance of 11 to provide extended TFCIs. The (32, 7-10) encoders can be implemented by controlling use of at least one of the five basis mask sequences generated from the basis mask sequence

generator 1420 and the mask sequence generator 1480 shown in FIG. 14.

FIG. 16 is a flowchart illustrating a third embodiment of the TFCI encoding procedure in the IMT 2000 system according to the present invention.

Referring to FIG. 16, 10 information bits (TFCI bits) a0 to a9 are received and variables sum and j are set to initial values 0s in step 1600. The variable sum indicates a final code symbol output after symbol-basis addition and the variable j indicates the count number of final code symbols output after the symbol-basis addition. It is determined whether j is 30 in step 1610 in view of the length 30 of punctured Walsh codes and mask sequences used for encoding. The purpose of performing step 1610 is to judge whether the input information bits are encoded with respect to the 30 symbols of each Walsh code and the 30 symbols of each mask sequence.

If j is not 30 in step 1610, which implies that encoding is not completed with respect to all the symbols of the Walsh codes and mask sequences, the j^{th} symbols W1(j), W2(j), W4(j), W8(j), and W16(j) of the basis Walsh codes W1, W2, W4, W8, and W16 and the j^{th} symbols M1(j), M2(j), M4(j), M8(j), and M16(j) of the basis mask sequences M1, M2, M4, M8, and M16 are received in step 1620. In step 1630, the input information bits are multiplied by the received symbols symbol by symbol and the symbol products are summed.

Step 1630 can be expressed as

$$sum = a0 \cdot M16(j) + a1 \cdot W1(j) + a2 \cdot W2(j) + a3 \cdot W4(j) + a4 \cdot W8(j) + a5 \cdot W16(j) + a6 \cdot M1(j) + a7 \cdot M2(j) + a8 \cdot M4(j) + a9 \cdot M8(j) \quad \ldots\ldots (Eq. 10)$$

As noted from Eq.10, an intended code symbol is obtained by multiplying each input information bit by the symbols of a corresponding basis Walsh code or basis mask sequence and summing the products.

In step 1640, sum indicating the achieved j^{th} code symbol is output. j is increased by 1 in step 1650 and then the procedure returns to step 1610. Meanwhile, if j is 30 in step 1610, the encoding procedure ends.

Now there will be given a description of the third embodiment of the decoding apparatus referring to FIG. 15. An input signal r(t) which includes the 30 encoded

symbols signal transmitted by a transmitter and two dummy symbols which have been inserted at the positions that have been punctured by the encoder is applied to 31 multipliers 1502 to 1506 and a correlation calculator 1520. A mask sequence generator 1500 generates all possible 31 mask sequences of length 32 M1 to M31. The multipliers 1502 to 1506 multiply the mask sequences received from the mask sequence generator 1500 by the input signal r(t). If a transmitter encoded TFCI bits with a predetermined mask sequence, one of the outputs of the multipliers 1502 to 1506 is free of the mask sequence, which means the mask sequence has no effect on the following correlation calculator. For example, if the transmitter used the mask sequence M31 for encoding the TFCI bits, the output of the multiplier 1506 that multiplies the mask sequence M31 by the input signal r(t) is free of the mask sequence. However, if the transmitter did not use a mask sequence, the input signal r(t) itself applied to a correlation calculator 1520 is a mask sequence-free signal. Each correlation calculators 1520 to 1526 calculates the correlation values of the outputs of the multipliers 1502 to 1506 with 64 bi-orthogonal codes of length 32, determines maximum correlation value among the 64-correlation sets, and outputs the determined maximum correlation values, the indexes of each bi-orthogonal codescorresponding to the determined maximum correlation values, and each indexe of the mask sequences to a correlation comparator 1540,respectively.

The correlation comparator 1540 compares the 32 maximum correlation values received from the correlation calculators 1520 to 1526 and determines the largest of the maximum correlation values as a final maximum correlation. Then, the correlation comparator 1540 outputs the decoded TFCI bits transmitted by the transmitter on the basis of the indexes of the bi-orthogonal code and mask sequence corresponding to the final maximum correlation value. As in FIG. 17, the third embodiment of present invention can be also implemented by a single multiplier for multiplying the masks with r(t) and a single correlation calculator for calculating correlation values of bi-orthogonal codes.

As described above, the present invention provides an apparatus and method for encoding and decoding a basic TFCI and an extended TFCI variably so that hardware is simplified. Another advantage is that support of both basic TFCI and extended TFCI error correcting coding schemes increases service stability. Furthermore, a minimum distance, a factor that determined the performance of an encoding apparatus, is large enough to satisfy the requirement of an IMT 2000 system, thereby ensuing excellent performance.

While the inv[illegible]n has been shown and described with reference to certain preferred embodiment[illegible]of, it will be understood by those skilled in the art that various changes in for[illegible] details may be made therein without departing from the spirit and scope of the i[illegible]ion as defined by the appended claims.

WHAT IS CLAIMED IS:

1. A transport format combination indicator (TFCI) encoding apparatus in a CDMA mobile communication system, comprising:

a one-bit generator for generating a sequence having the same symbols;

a basis orthogonal sequence generator for generating a plurality of basis orthogonal sequences;

a basis mask sequence generator for generating a plurality of basis mask sequences; and

an operation unit for receiving TFCI bits that are divided into a first information part representing biorthogonal sequence conversion, a second information part representing orthogonal sequence conversion, and a third information part representing mask sequence conversion and adding an orthogonal sequence selected from the basis orthogonal sequence based on the second information part and a mask sequence selected based on the third information part.

2. The TFCI encoding apparatus of claim 1, wherein the same symbols are 1s.

3. The TFCI encoding apparatus of claim 1, wherein the plurality of basis orthogonal sequences are a first Walsh code, a second Walsh code, a fourth Walsh code, an eighth Walsh code, and a sixteenth Walsh code.

4. The TFCI encoding apparatus of claim 1, wherein the basis mask sequences includes
a first mask sequence "00101000011000111111000001110111", a second mask sequence "00000001110011010110110111000111", a fourth mask sequence "00001010111110010001101100101011", and an eighth mask sequence "00011100001101110010111101010001".

5. The TFCI encoding apparatus of claim 1, wherein the operation unit further comprises a converter for providing bi-orthogonal sequences by complementing the orthogonal sequences.

6. The TFCI encoding apparatus of claim 5, wherein the converter is an adder for adding a '1' to the symbols in each of the orthogonal sequences.

7. The TFCI encoding apparatus of claim 1, wherein the basis mask sequence length is 32 symbols.

8. The TFCI encoding apparatus of claim 1, wherein the basis mask sequence generator has a first m-sequence and a second m-sequence which can be added together to form a Gold code, forms a first sequence group having sequences formed by cyclically shifting the first m-sequence and a second sequence group having sequences formed by cyclically shifting the second m-sequence, generates a column transposition function to convert the sequences in the first group into the orthogonal sequences, inserts a column of '0' in the front of the sequences in the second group, and generates and applies a reverse column transposition function to the sequences in the second group to convert the sequences in the second group into the mask sequences.

9. The TFCI encoding apparatus of claim 8, wherein the basis mask sequences are a first mask sequence "00101000011000111111000001110111", a second mask sequence "00000001110011010110110111000111", a fourth mask sequence "00001010111110010001101100101011", and an eighth mask sequence "00011100001101110010111101010001".

10. The TFCI encoding apparatus of claim 1, wherein the operation unit comprises:

a first multiplier for multiplying the same symbols by the first information part;

a plurality of second multipliers for multiplying the basis orthogonal sequences by the respective TFCI bits representing the second information part;

a plurality of third multipliers for multiplying the basis mask sequences by the respective TFCI bits representing the third information part; and

an adder for adding the outputs of the first, second, and third multipliers.

11. A TFCI encoding apparatus in a CDMA mobile communication system, comprising:

an orthogonal sequence generator for generating a plurality of basis biorthogonal sequences;

a mask sequence generator for generating a plurality of basis mask sequences; and

an operation unit for adding a basis biorthogonal sequence and a basis mask sequence selected among the basis biorthogonal sequences and the basis mask sequences according to TFCI bits.

12. The TFCI encoding apparatus of claim 11, wherein the plurality of basis biorthogonal sequences are a first Walsh code, a second Walsh code, a fourth Walsh code, an eighth Walsh code, a sixteenth Walsh code and an all "1" sequence which converts the orthogonal sequences to the biorthogonal sequences.

13. The TFCI encoding apparatus of claim 11, wherein the mask sequence generator has a first m-sequence and a second m-sequence which can be added together to form a Gold code, forms a first sequence group having sequences formed by cyclically shifting the first m-sequence and a second sequence group having sequences formed by cyclically shifting the second m-sequence, generates and applies a column transposition function to the sequences in the first group to convert the sequences in the first group to orthogonal sequences, inserts a column of '0' in the front of the sequences in the second group, and generates and applies a reverse column transposition function to the sequences in the second group to convert the sequences in the second group to mask sequences.

14. The TFCI encoding apparatus of claim 11, wherein the basis mask sequences are a first mask sequence "00101000011000111111000001110111", a second mask sequence "00000001110011010110110111000111", a fourth mask sequence "00001010111110010001101100101011", and an eighth mask sequence "00011100001101110010111101010001".

15. The TFCI encoding apparatus of claim 11, wherein the operation unit comprises:

a plurality of first multipliers for multiplying the basis biorthogonal sequences by corresponding TFCI bits;

a plurality of second multipliers for multiplying the basis mask sequences by corresponding TFCI bits; and

an adder for adding the outputs of the first and second multipliers and generating the sum as the TFCI sequence.

16. An apparatus for encoding TFCI bits including first information bits and second information bits in a CDMA mobile communication system, comprising:

an orthogonal sequence generator for generating a plurality of biorthogonal sequences and outputting a biorthogonal sequence selected based on the first information bits among the plurality of biorthogonal sequences;

a mask sequence generator for generating a plurality of mask sequences and outputting a mask sequence selected based on the second information bits among the plurality of mask sequences; and

an adder for adding the biorthogonal sequence and the mask sequence received from the orthogonal sequence generator.

17. The TFCI encoding apparatus of claim 12, wherein the plurality of biorthogonal sequences are Walsh codes andbi-orthogonal complement sequences of the Walsh codes.

18. The TFCI encoding apparatus of claim 16, wherein the mask sequence generator has a first m-sequence and a second m-sequence which can be added together to form a Gold code, forms a first sequence group having sequences formed by cyclically shifting the first m-sequence and a second sequence group having sequences formed by cyclically shifting the second m-sequence, generates and applies a column transposition function to the sequences in the first group to convert the sequences in the first group to orthogonal sequences, inserts a column of '0' in the front of the sequences in the second group, and generates and applies a reverse column transposition function to the sequences in the second group to convert the sequences in the second group to the mask sequences.

19. A TFCI encoding apparatus in a CDMA mobile communication system, comprising:

a one-bit generator for generating a sequence having the same symbols;

an orthogonal sequence generator for generating a plurality of basis orthogonal sequences;

a mask sequence generator for generating a plurality of basis mask sequences;

a plurality of multipliers as many as input TFCI bits, for multiplying the same symbols by corresponding TFCI bits, the plurality of basis orthogonal sequences by corresponding TFCI bits, and the plurality of basis mask sequences by corresponding TFCI bits; and

an adder for summing sequences received from the plurality of multipliers.

20. The TFCI encoding apparatus of claim 15, wherein the same symbols are 1s.

21. The TFCI encoding apparatus of claim 15, wherein the plurality of

basis orthogonal sequences are a first Walsh code, a second Walsh code, a fourth Walsh code, an eighth Walsh code, and a sixteenth Walsh code.

22. The TFCI encoding apparatus of claim 19, wherein the mask sequence generator has a first m-sequence and a second m-sequence which can be added together to form a Gold code, forms a first sequence group having sequences formed by cyclically shifting the first m-sequence and a second sequence group having sequences formed by cyclically shifting the second m-sequence, generates and applies a column transposition function to the sequences in the first group to convert the sequences in the first group to the orthogonal sequences, inserts a column of '0' in the front of the sequences in the second group, and generates and applies a reverse column transposition function to the sequences in the second group to convert the sequences in the second group to the mask sequences.

23. The TFCI encoding apparatus of claim 19, wherein the basis mask sequences are a first mask sequence "00101000011000111111000001110111", a second mask sequence "00000001110011010110110111000111", a fourth mask sequence "00001010111110010001101100101011", and an eighth mask sequence "00011100001101110010111101010001".

24. A TFCI encoding method in a CDMA mobile communication system, comprising the steps of:

generating the same symbols;

generating a plurality of basis orthogonal sequences;

generating a plurality of basis mask sequences; and

receiving TFCI bits that are divided into a first information part representing biorthogonal sequence conversion, a second information part representing orthogonal sequence conversion, and a third information part representing mask sequence conversion and combining an orthogonal sequence selected from the basis orthogonal sequence based on the second information part, a biorthogonal sequence obtained by combining the selected orthogonal sequence with the same symbols selected based on the first information part, and a mask sequence selected based on the biorthogonal sequence and the third information part.

25. The TFCI encoding method of claim 24, wherein the same symbols are 1s.

26. The TFCI encoding method of claim 24, wherein the plurality of basis orthogonal sequences are a first Walsh code, a second Walsh code, a fourth Walsh code, an eighth Walsh code, and a sixteenth Walsh code.

27. The TFCI encoding apparatus of claim 24, wherein the mask sequence generator has a first m-sequence and a second m-sequence which can be added together to form a Gold code, forms a first sequence group having sequences formed by cyclically shifting the first m-sequence and a second sequence group having sequences formed by cyclically shifting the second m-sequence, generates and applies a column transposition function to the sequences in the first group to convert the sequences in the first group to the orthogonal sequences, inserts a column of '0' in the front of the sequences in the second group, and generates and applies a reverse column transposition function to the sequences in the second group to convert the sequences in the second group to the mask sequences.

28. The TFCI encoding method of claim 24, wherein the basis mask sequences are a first mask sequence "00101000011000111111000001110111", a second mask sequence "00000001110011010110110111000111", a fourth mask sequence "00001010111110010001101100101011", and an eighth mask sequence "00011100001101110010111101010001".

29. The TFCI encoding method of claim 24, wherein the same symbols are multiplied by the first information part, the basis orthogonal sequences are multiplied by the respective TFCI bits representing the second information part, the basis mask sequences are multiplied by the respective TFCI bits representing the third information part, and the multiplication results are summed.

30. A TFCI encoding method in a CDMA mobile communication system, comprising the steps of:

generating a plurality of basis biorthogonal sequences;

generating a plurality of basis mask sequences; and

adding a basis biorthogonal sequence and a basis mask sequence selected among the basis biorthogonal sequences and the basis mask sequences according to TFCI bits.

31. The TFCI encoding method of claim 30, wherein the plurality of basis biorthogonal sequences are a first Walsh code, a second Walsh code, a fourth Walsh

code, an eighth Walsh code, a sixteenth Walsh code and an all "1" sequence which converts the orthogonal sequences to the biorthogonal sequences.

32. The TFCI encoding apparatus of claim 30, wherein the mask sequence generator has a first m-sequence and a second m-sequence which can be added together to form a Gold code, forms a first sequence group having sequences formed by cyclically shifting the first m-sequence and a second sequence group having sequences formed by cyclically shifting the second m-sequence, generates and applies a column transposition function to the sequences in the first group to convert the sequences in the first group to orthogonal sequences, inserts a column of '0' in the front of the sequences in the second group, and generates and applies a reverse column transposition function to the sequences in the second group to convert the sequences in the second group to the mask sequences.

33. The TFCI encoding method of claim 30, wherein the basis mask sequences are a first mask sequence "00101000011000111111000001110111", a second mask sequence "00000001110011010110110111000111", a fourth mask sequence "00001010111110010001101100101011", and an eighth mask sequence "00011100001101110010111101010001".

34. The TFCI encoding method of claim 30, wherein the basis orthogonal sequences are multiplied by corresponding TFCI bits, the basis mask sequences are multiplied by corresponding TFCI bits, and the multiplication results are added to the TFCI sequence in the TFCI sequence generating step.

35. A method of encoding TFCI bits including first information bits and second information bits in a CDMA mobile communication system, comprising the steps of:

generating a plurality of biorthogonal sequences and outputting a biorthogonal sequence selected based on the first information bits among the plurality of biorthogonal sequences;

generating a plurality of mask sequences and outputting a mask sequence selected based on the second information bits among the plurality of mask sequences; and

adding the selected biorthogonal sequence and the selected mask sequence.

36. The TFCI encoding method of claim 35, wherein the plurality of

biorthogonal sequences are Walsh codes and complement codes of the Walsh codes.

37. The TFCI encoding apparatus of claim 35, wherein the mask sequence generator has a first m-sequence and a second m-sequence which can be added together to form a Gold code, forms a first sequence group having sequences formed by cyclically shifting the first m-sequence and a second sequence group having sequences formed by cyclically shifting the second m-sequence, generates and applies a column transposition function to the sequences in the first group to convert the sequences in the first group to orthogonal sequences, inserts a column of '0' in the front of the sequences in the second group, and generates and applies a reverse column transposition function to the sequences in the second group to convert the sequences in the second group to the mask sequences.

38. A TFCI encoding method in a CDMA mobile communication system, comprising the steps of:

generating the same symbols;

generating a plurality of basis orthogonal sequences;

generating a plurality of basis mask sequences;

receiving TFCI bits and multiplying the same symbols by corresponding TFCI bits, the plurality of basis orthogonal sequences by corresponding TFCI bits, and the plurality of basis mask sequences by corresponding TFCI bits; and

adding the multiplication results.

39. The TFCI encoding method of claim 38, wherein the same symbols are 1s.

40. The TFCI encoding method of claim 38, wherein the plurality of basis orthogonal sequences are a first Walsh code, a second Walsh code, a fourth Walsh code, an eighth Walsh code, and a sixteenth Walsh code.

41. The TFCI encoding apparatus of claim 38, wherein the mask sequence generator has a first m-sequence and a second m-sequence which can be added together to form a Gold code, forms a first sequence group having sequences formed by cyclically shifting the first m-sequence and a second sequence group having sequences formed by cyclically shifting the second m-sequence, generates and applies a column transposition function to the sequences in the first group to convert the sequences in the first group to the orthogonal sequences, inserts a column of '0' in the front of the sequences in the

second group, and generates and applies a reverse column transposition function to the sequences in the second group to convert the sequences in the second group to the mask sequences.

42. The TFCI encoding method of claim 38, wherein the basis mask sequences are a first mask sequence "00101000011000111111000001110111", a second mask sequence "00000001110011010110110111000111", a fourth mask sequence "00001010111110010001101100101011", and an eighth mask sequence "00011100001101110010111101010001".

43. A TFCI decoding apparatus in a CDMA mobile communication system, comprising:

a mask sequence generator for generating at least one mask sequence;

at least one operation circuit for receiving an input signal and the generated mask sequence and removing the mask sequences from the input signal by multiplying the mask sequence by the input signal; and

at least one correlator for receiving the signal from the operation circuit, calculating correlation values of the received signal with a plurality of orthogonal sequences numbered with corresponding indexes, and selecting the largest of the calculated correlation value and the orthogonal sequence index corresponding to the largest correlation value.

44. The TFCI encoding apparatus of claim 43, wherein the mask sequence generator has a first m-sequence and a second m-sequence which can be added together to form a Gold code, forms a first sequence group having sequences formed by cyclically shifting the first m-sequence and a second sequence group having sequences formed by cyclically shifting the second m-sequence, generates and applies a column transposition function to the sequences in the first group to convert the sequences in the first group to orthogonal sequences, inserts a column of '0' in the front of the sequences in the second group, and generates and applies a reverse column transposition function to the sequences in the second group to convert the sequences in the second group to the mask sequences.

45. The TFCI decoding apparatus of claim 43, wherein the operation circuit is a multiplier.

46. The TFCI decoding apparatus of claim 43, further comprising a

correlation comparator for determining the largest correlation value received from a plurality of correlators and generating an orthogonal sequence index and a mask sequence index corresponding to the largest correlation value.

47. The TFCI decoding apparatus of claim 46, wherein the mask sequence index is the index of the mask sequence used to remove a mask sequence from the input signal.

48. A TFCI decoding apparatus in a CDMA mobile communication system, comprising;

a mask sequence generator for sequentially generating a plurality of mask sequences;

an operation circuit for receiving an input signal and the mask sequences from the mask sequence generator, and removing a mask sequence form the input signal by multiplying the mask sequences by the input signal;

a correlator for receiving signals from the operation circuit sequentially, calculating correlation value of each received signal with a plurality of orthogonal sequences having corresponding indexes, and sequentially selecting the largest correlation values and an orthogonal sequence index corresponding to the largest correlation value; and

a correlation comparator for determining the highest correlation value out of the sequentially selected largest correlation values, from the correlator and outputting an orthogonal sequence index and a mask sequence index corresponding to the determined highest correlation value.

49. The TFCI encoding apparatus of claim 48, wherein the mask sequence generator has a first m-sequence and a second m-sequence which can be added together to form a Gold code, forms a first sequence group having sequences formed by cyclically shifting the first m-sequence and a second sequence group having sequences formed by cyclically shifting the second m-sequence, generates and applies a column transposition function to the sequences in the first group to convert the sequences in the first group to orthogonal sequences, inserts a column of '0' in the front of the sequences in the second group, and generates and applies a reverse column transposition function to the sequences in the second group to convert the sequences in the second group to the mask sequences.

50. The TFCI decoding apparatus of claim 48, further comprising a

memory for storing the input signal and outputting the input signal to the operation circuit until the input signal is completely multiplied by the mask sequences generated from the mask sequence generator.

51. The TFCI decoding apparatus of claim 50, wherein the operation circuit is a multiplier.

52. The TFCI decoding apparatus of claim 48, wherein the mask sequence index is the index of the mask sequence used to remove a mask sequence from the input signal.

53. A TFCI decoding apparatus in a CDMA mobile communication system, comprising;

a mask sequence generator for sequentially generating a plurality of mask sequences;

a plurality of operation circuits for receiving an input signal and the mask sequences from the mask sequence generator and multiplying the mask sequences by the input signal;

a first correlator for calculating correlation values of the received signal with a plurality of orthogonal sequences, selecting the largest correlation value and an orthogonal sequence index corresponding to the largest correlation value;

a plurality of secondary correlators for receiving the input signal and the outputs of the operation circuits, calculating correlation values of the received signals with a plurality of orthogonal sequences having corresponding indexes, and selecting the largest correlation value and orthogonal sequences index corresponding to the largest correlation value, respectably; and

a correlation comparator for determining the highest correlation value from the selected largest correlation values received from the correlators and outputting TFCI information based on an orthogonal sequence index and a mask sequence index corresponding to the determined highest correlation value.

54. The TFCI encoding apparatus of claim 53, wherein the mask sequence generator has a first m-sequence and a second m-sequence which can be added together to form a Gold code, forms a first sequence group having sequences formed by cyclically shifting the first m-sequence and a second sequence group having sequences formed by cyclically shifting the second m-sequence, generates and applies a column transposition function to the sequences in the first group to convert the sequences in the first group to

orthogonal sequences, inserts a column of '0' in the front of the sequences in the second group, and generates and applies a reverse column transposition function to the sequences in the second group to convert the sequences in the second group to the mask sequences.

55. The TFCI decoding apparatus of claim 54, wherein the operation circuits are multipliers.

56. The TFCI decoding apparatus of claim 53, wherein the mask sequence index is the index of the mask sequence used to remove a mask sequence from the input signal corresponding to the determined correlation value.

57. A TFCI decoding method in a CDMA mobile communication system, comprising the steps of:

generating at least one mask sequence;

receiving an input signal and the mask sequence and removing a mask sequence from the input signal by multiplying the mask sequence by the input signal;

receiving the product signal, calculating correlation values of the product signal with a plurality of orthogonal sequences having corresponding indexes; and

selecting the largest correlation value from the calculated correlation values and outputting an orthogonal sequence index corresponding to the largest correlation value.

58. The TFCI encoding apparatus of claim 57, wherein the mask sequence generator has a first m-sequence and a second m-sequence which can be added together to form a Gold code, forms a first sequence group having sequences formed by cyclically shifting the first m-sequence and a second sequence group having sequences formed by cyclically shifting the second m-sequence, generates and applies a column transposition function to the sequences in the first group to convert the sequences in the first group to orthogonal sequences, inserts a column of '0' in the front of the sequences in the second group, and generates and applies a reverse column transposition function to the sequences in the second group to convert the sequences in the second group to the mask sequences.

59. The TFCI decoding method of claim 57, further comprising the step of

determining the highest correlation value from the selected largest correlation values obtained by selecting the largest correlation value from the calculated correlation values ;

and outputting an orthogonal sequence index and a mask sequence index corresponding to the determined highest correlation value.

60. The TFCI decoding apparatus of claim 59, wherein the mask sequence index is the index of the mask sequence used to remove a mask sequence from the input signal corresponding to the highest correlation value.

61. A TFCI decoding method in a CDMA mobile communication system, comprising the steps of:

generating a plurality of mask sequences;

receiving an input signal and the mask sequences and removing a mask sequence from the input signal by multiplying the mask sequences by the input signal;

receiving the product signals, calculating correlation values of each of the product signals with a plurality of orthogonal sequences having corresponding indexes, and selecting the largest correlation values and orthogonal sequence indexes corresponding to the largest correlation values; and

determining the highest correlation value from the largest correlation values and outputting an orthogonal sequence index and a mask sequence index corresponding to the determined highest correlation value.

62. The TFCI encoding apparatus of claim 61, wherein the mask sequence generator has a first m-sequence and a second m-sequence which can be added together to form a Gold code, forms a first sequence group having sequences formed by cyclically shifting the first m-sequence and a second sequence group having sequences formed by cyclically shifting the second m-sequence, generates and applies a column transposition function to the sequences in the first group to convert the sequences in the first group to orthogonal sequences, inserts a column of '0' in the front of the sequences in the second group, and generates and applies a reverse column transposition function to the sequences in the second group to convert the sequences in the second group to the mask sequences.

63. The TFCI decoding method of claim 61, wherein the mask sequence index is the index of the mask sequence used to remove a mask sequence from the input signal corresponding to the highest correlation value.

64. A TFCI decoding method in a CDMA mobile communication system, comprising the steps of:

generating a plurality of mask sequences;

receiving an input signal and the mask sequences and multiplying each mask sequence by the input signal;

receiving the multiplied signals and calculating correlation values of each of the received multiplied signals with a plurality of orthogonal sequences having corresponding indexes;

selecting the largest correlation value among the calculated correlation values for each of the multiplied signals and an orthogonal sequence index corresponding to the largest correlation value; and ;

determining the highest correlation value from all of the largest correlation values and an orthogonal code index corresponding to the highest correlation value

65. The TFCI encoding apparatus of claim 64, wherein the mask sequence generator has a first m-sequence and a second m-sequence which can be added together to form a Gold code, forms a first sequence group having sequences formed by cyclically shifting the first m-sequence and a second sequence group having sequences formed by cyclically shifting the second m-sequence, generates and applies a column transposition function to the sequences in the first group to convert the sequences in the first group to orthogonal sequences, inserts a column of '0' in the front of the sequences in the second group, and generates and applies a reverse column transposition function to the sequences in the second group to convert the sequences in the second group to the mask sequences.

66. The TFCI decoding method of claim 64, wherein the mask sequence index is the index of the mask sequence used to remove a mask sequence from the input signal corresponding to the highest correlation value.

67. A mask sequence generating method for use in a TFCI encoding and decoding, comprising the steps of:

selecting a Gold sequence which is determined by adding a first m-sequence and a second m-sequence, each of the m-sequences generated by different generation polynomials;

generating a first m-sequence group by cyclically shifting the first m-sequence where the first m-sequence is shifted one to 'n'times, 'n' is a length of the first and second m-sequences and each shift of the first m-sequence produces a sequence forming the first m-sequence group;

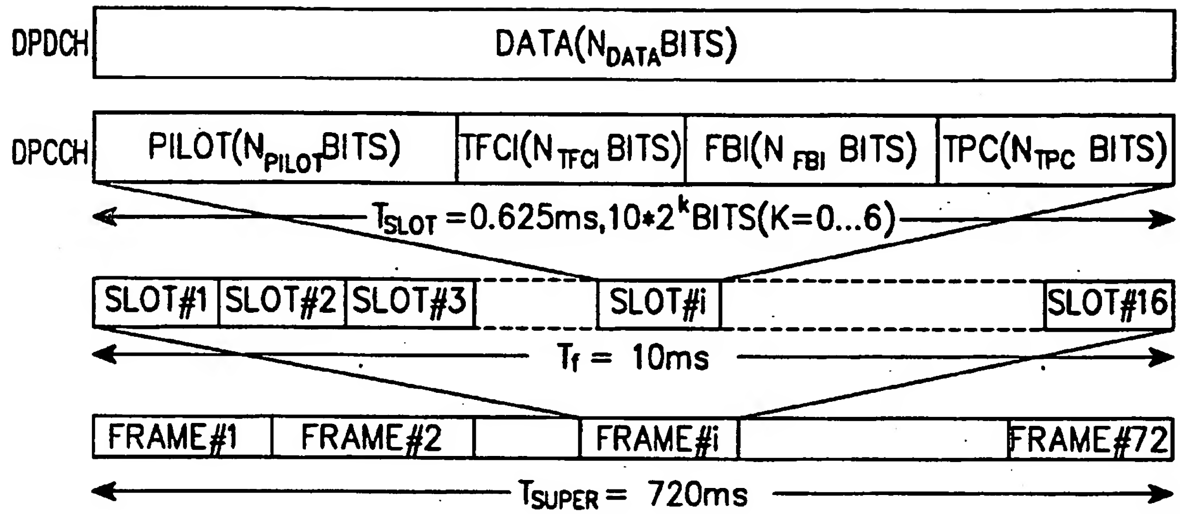
generating a second m-sequence group by cyclically shifting the second m-

sequence where the second m-sequence is shifted one to 'n' times and each shift of the second m-sequence produces a sequence forming the second m-sequence group;

determining a column transposition function that converts sequences in the first m-sequence group to orthogonal sequences;

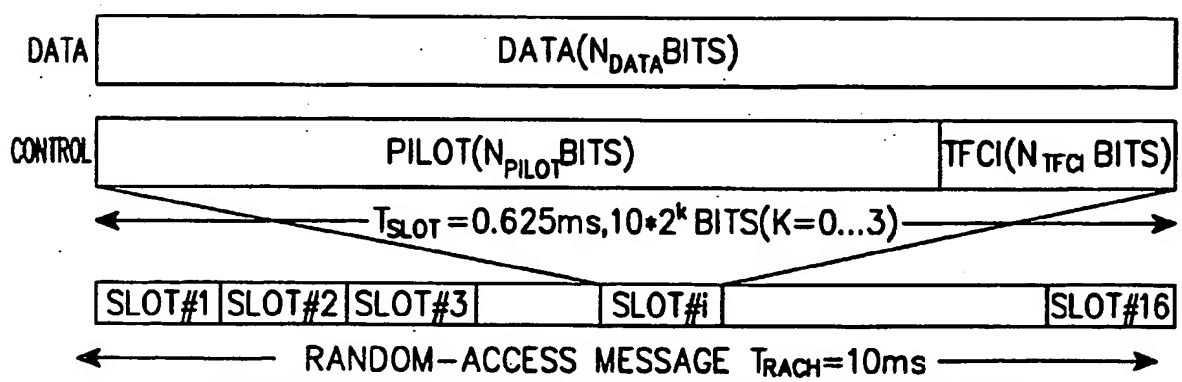
inserting a column of '0' in the front of the sequences in the second m-sequence group;

column changing the second m-sequence group by applying the reverse function of the sequence transposition function to generate mask sequences of the TFCI coding/decoding.



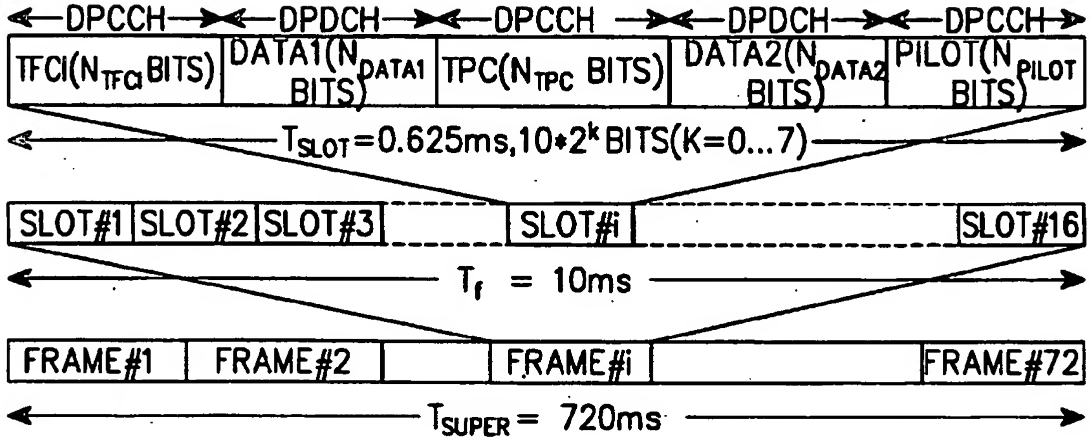
FRAME STRUCTURE FOR UPLINK DPDCH/DPCCH

FIG. 1A



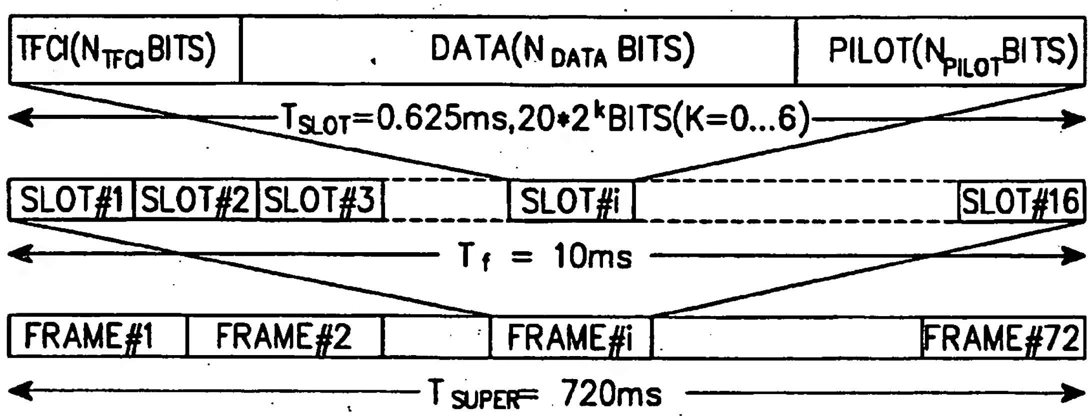
STUCTURE OF THE RANDOM-ACCESS MESSAGE PART

FIG. 1B



FRAME STRUCTURE OF DOWNLINK DPCH

FIG. 1C



FRAME STRUCTURE FOR SECONDARY COMMON CONTROL PHYSICAL CHANNEL

FIG. 1D

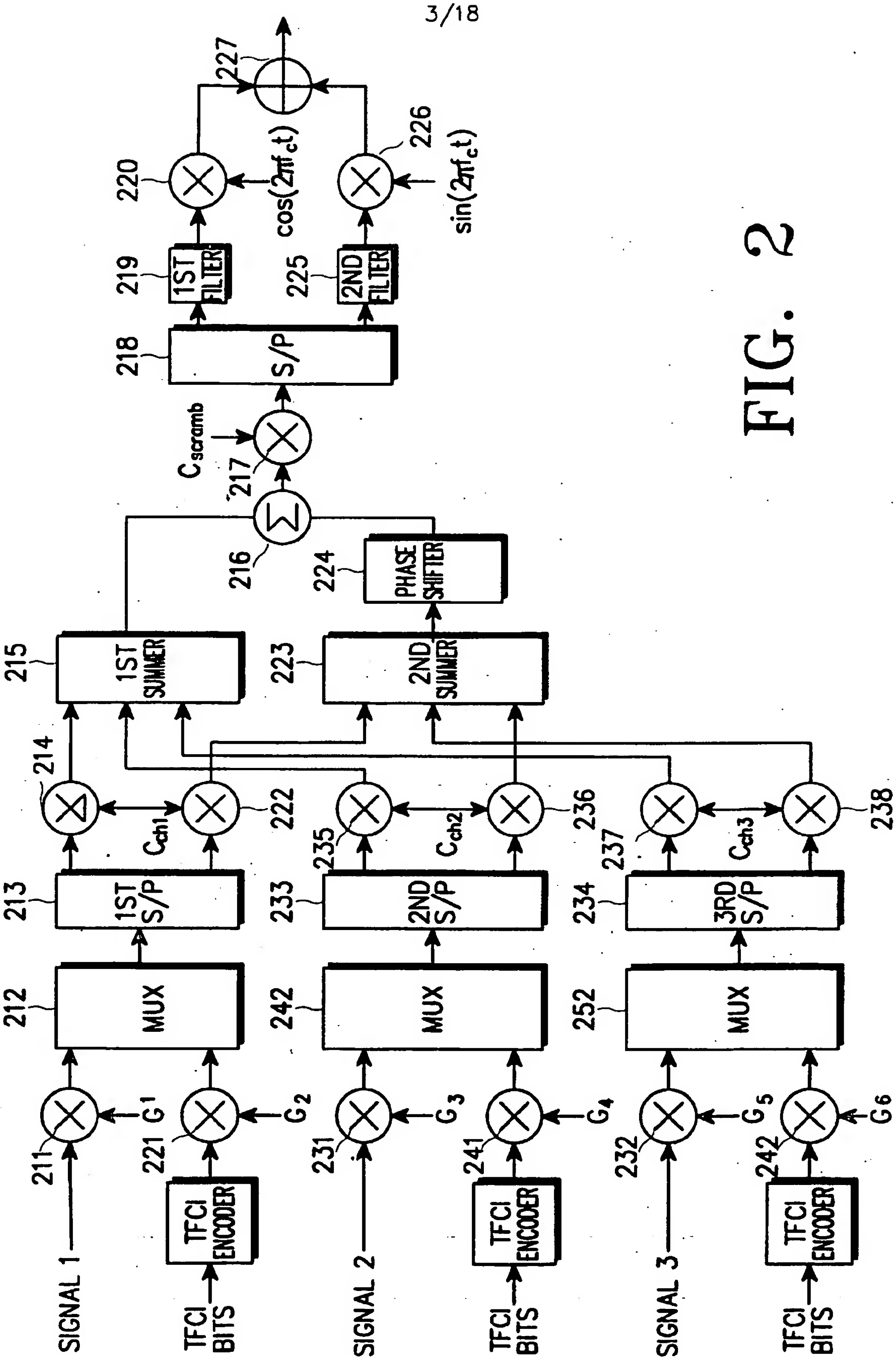
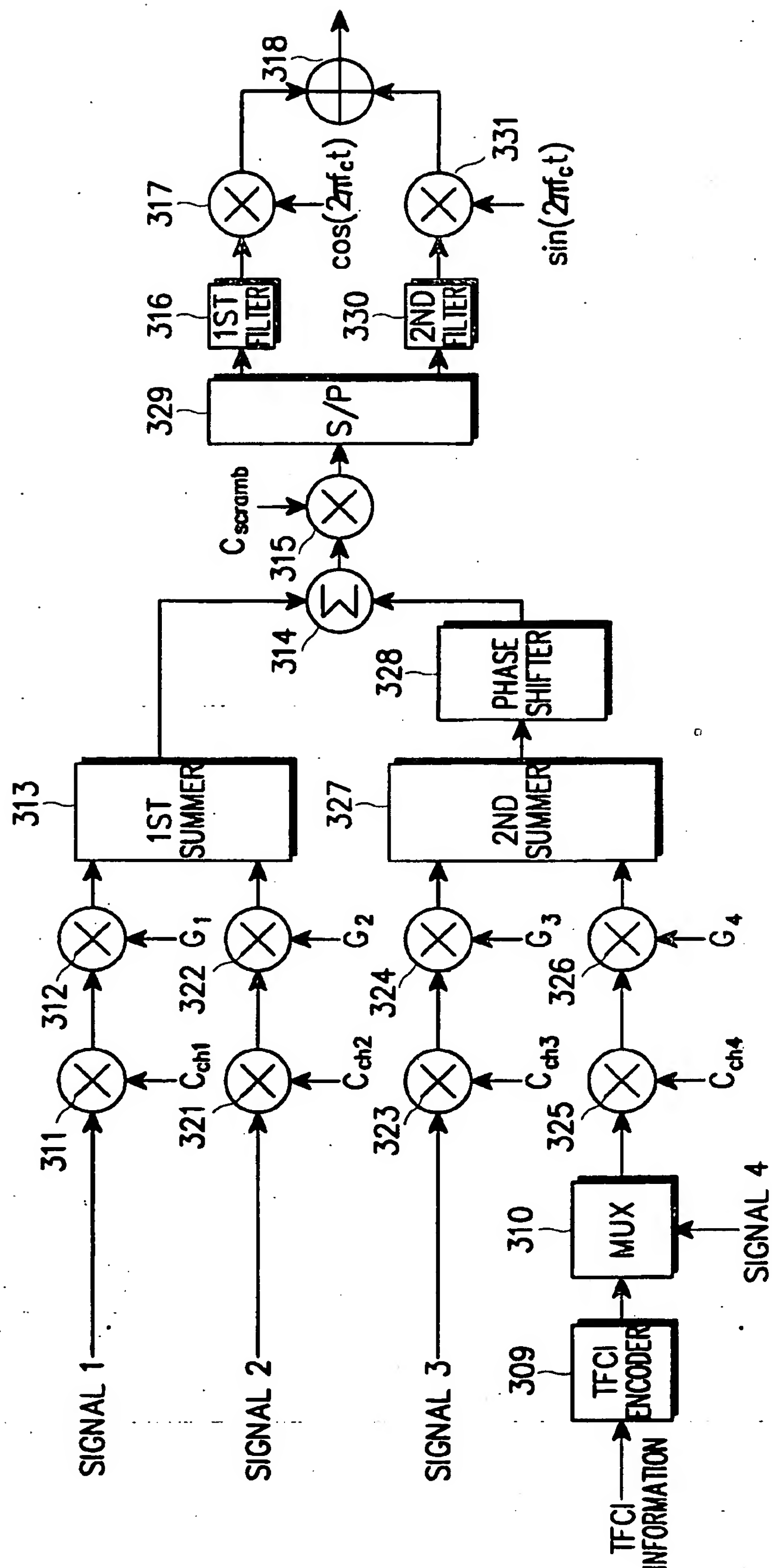

SIGNAL 1
TFCI BITS
TFCI ENCODER
SIGNAL 2
TFCI BITS
TFCI ENCODER
SIGNAL 3
TFCI BITS
TFCI ENCODER
MUX
MUX
MUX
1ST S/P
2ND S/P
3RD S/P
1ST SUMMER
2ND SUMMER
PHASE SHIFTER
S/P
1ST FILTER
2ND FILTER
Cch1
Cch2
Cch3
Cscramb
cos(2πfct)
sin(2πfct)
211
212
213
214
215
216
217
218
219
220
221
222
223
224
225
226
227
231
232
233
234
235
236
237
238
241
242
242
252

FIG. 2

FIG. 3


SIGNAL 1
SIGNAL 2
SIGNAL 3
SIGNAL 4
TFCI INFORMATION
TFCI ENCODER
MUX
1ST SUMMER
2ND SUMMER
PHASE SHIFTER
S/P
1ST FILTER
2ND FILTER
C_{ch1}
C_{ch2}
C_{ch3}
C_{ch4}
G_1
G_2
G_3
G_4
C_{scramb}
$\cos(2\pi f_c t)$
$\sin(2\pi f_c t)$
309
310
311
312
313
314
315
316
317
318
321
322
323
324
325
326
327
328
329
330
331

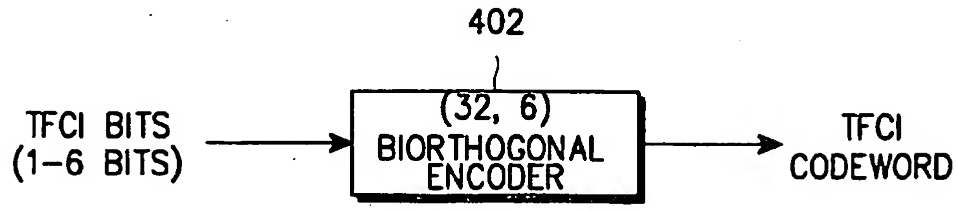

402
TFCI BITS (1-6 BITS)
(32, 6) BIORTHOGONAL ENCODER
TFCI CODEWORD

FIG. 4A

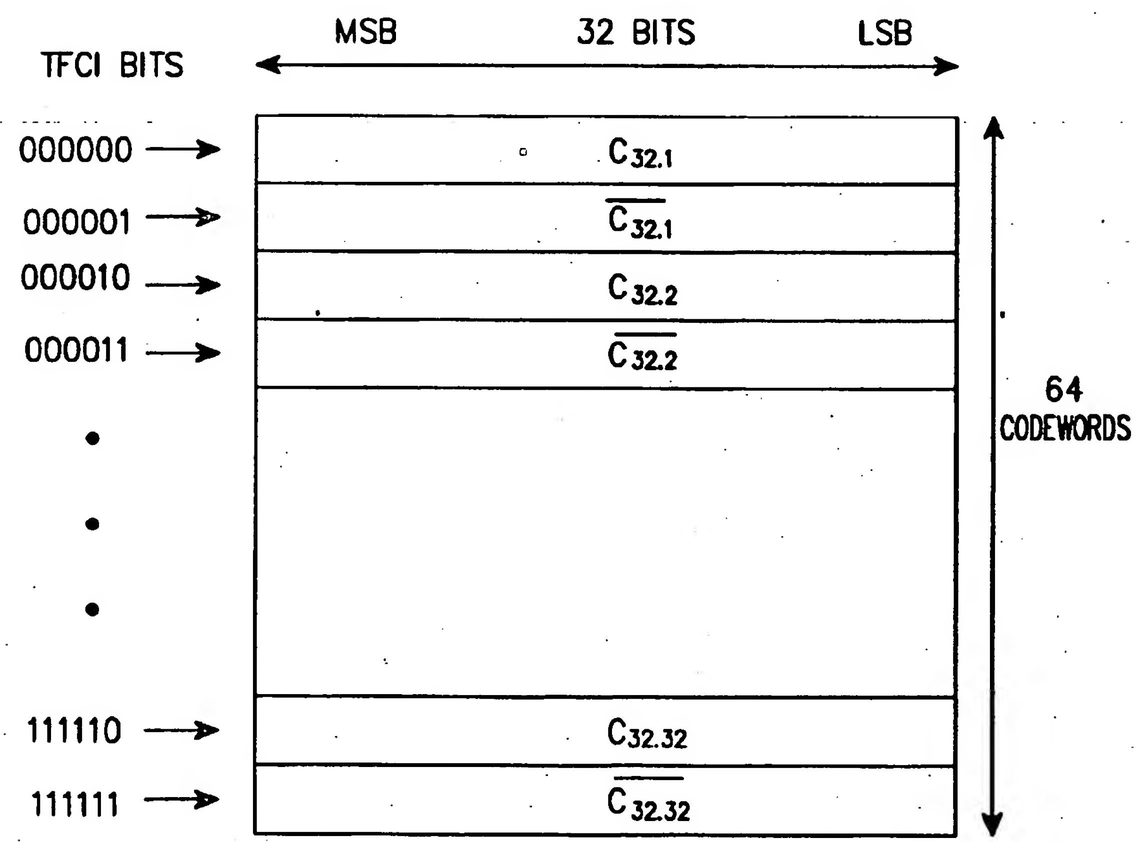

MSB
32 BITS
LSB
TFCI BITS
000000
000001
000010
000011
111110
111111
$C_{32.1}$
$\overline{C_{32.1}}$
$C_{32.2}$
$\overline{C_{32.2}}$
$C_{32.32}$
$\overline{C_{32.32}}$
64 CODEWORDS

FIG. 4B

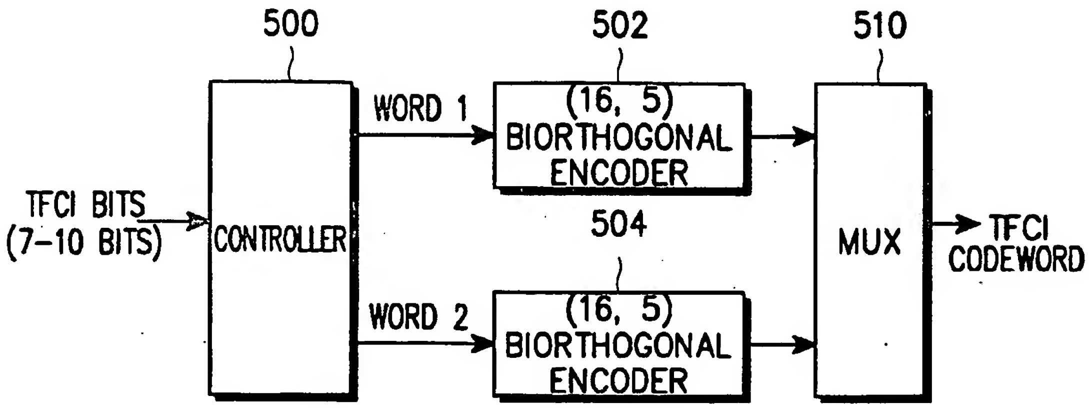


FIG. 5A

TFCI = $a_{10}a_9a_8a_7a_6a_5a_4a_3a_2a_1$

n = (MAXIMUM INTEGER EQUAL TO OR SMALLER THAN(TFCI)
IF TFCI < n^2+ n
THEN WORD1 = n ; WORD2 = TFCI−n^2
ELSE WORD1 = TFCI − n^2; WORD2 = n

FIG. 5B

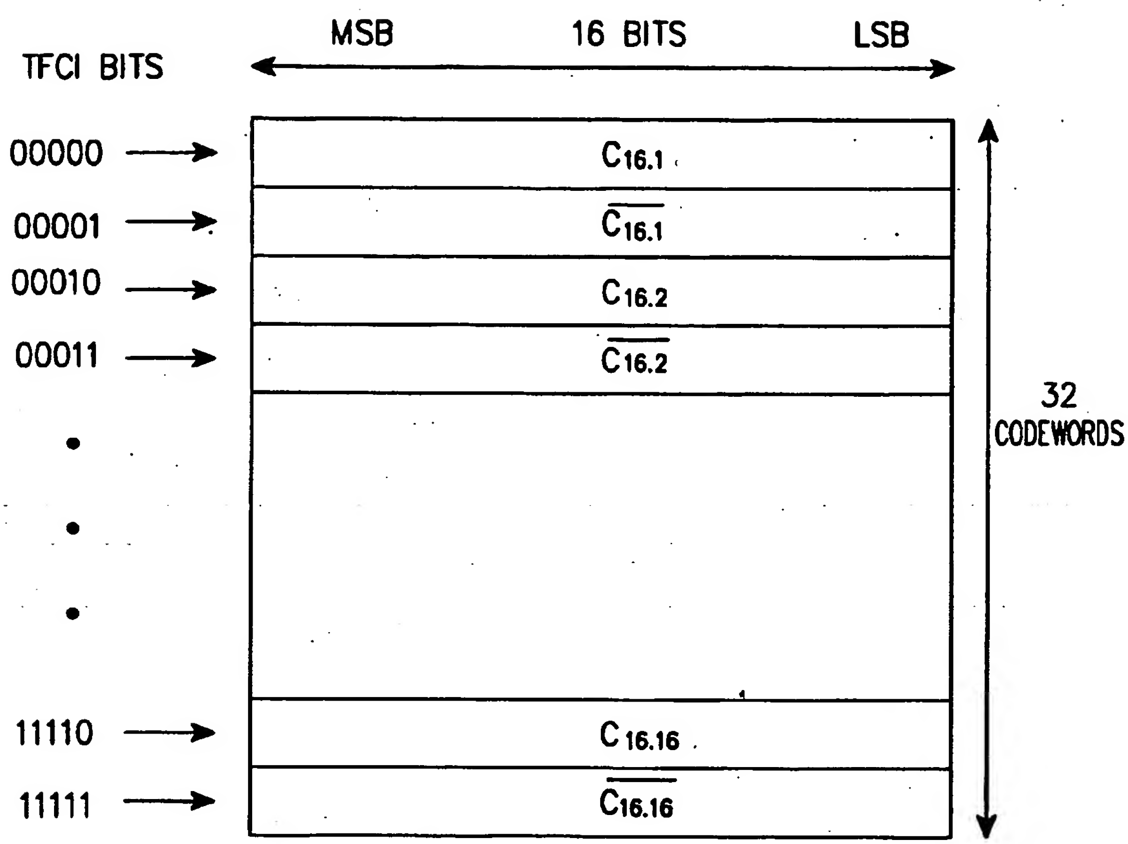

MSB
16 BITS
LSB
TFCI BITS
00000
00001
00010
00011
11110
11111
$C_{16.1}$
$\overline{C_{16.1}}$
$C_{16.2}$
$\overline{C_{16.2}}$
$C_{16.16}$
$\overline{C_{16.16}}$
32
CODEWORDS

FIG. 5C

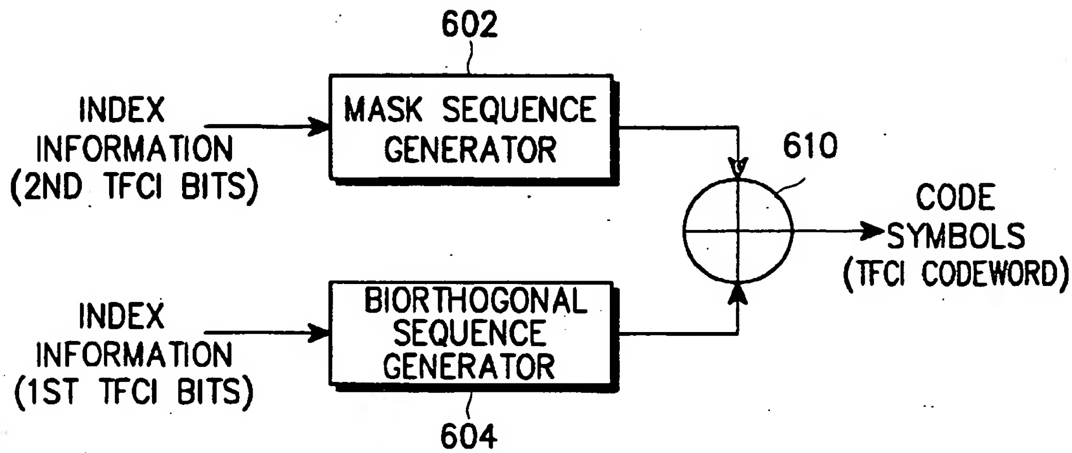

602
INDEX
INFORMATION
(2ND TFCI BITS)
MASK SEQUENCE
GENERATOR
610
CODE
SYMBOLS
(TFCI CODEWORD)
INDEX
INFORMATION
(1ST TFCI BITS)
BIORTHOGONAL
SEQUENCE
GENERATOR
604

FIG. 6

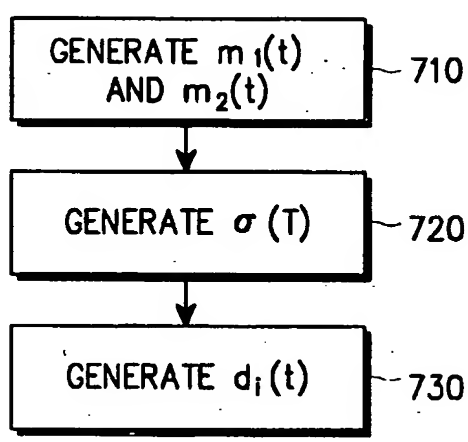
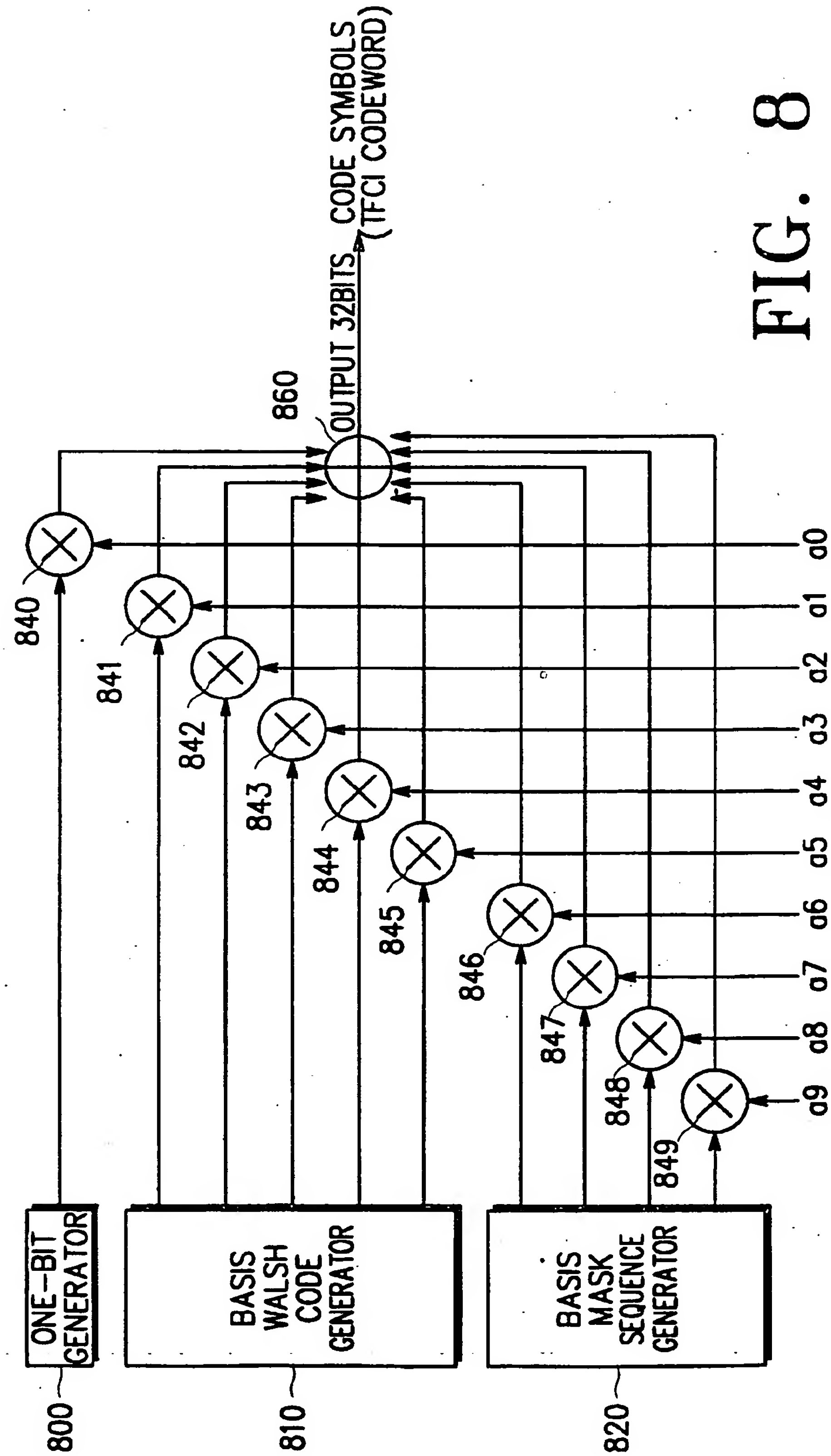

GENERATE $m_1(t)$
AND $m_2(t)$
710
GENERATE σ (T)
720
GENERATE $d_i(t)$
730

FIG. 7



ONE-BIT GENERATOR
BASIS WALSH CODE GENERATOR
BASIS MASK SEQUENCE GENERATOR
800
810
820
840
841
842
843
844
845
846
847
848
849
860
a0
a1
a2
a3
a4
a5
a6
a7
a8
a9
OUTPUT 32BITS CODE SYMBOLS (TFCI CODEWORD)

FIG. 8

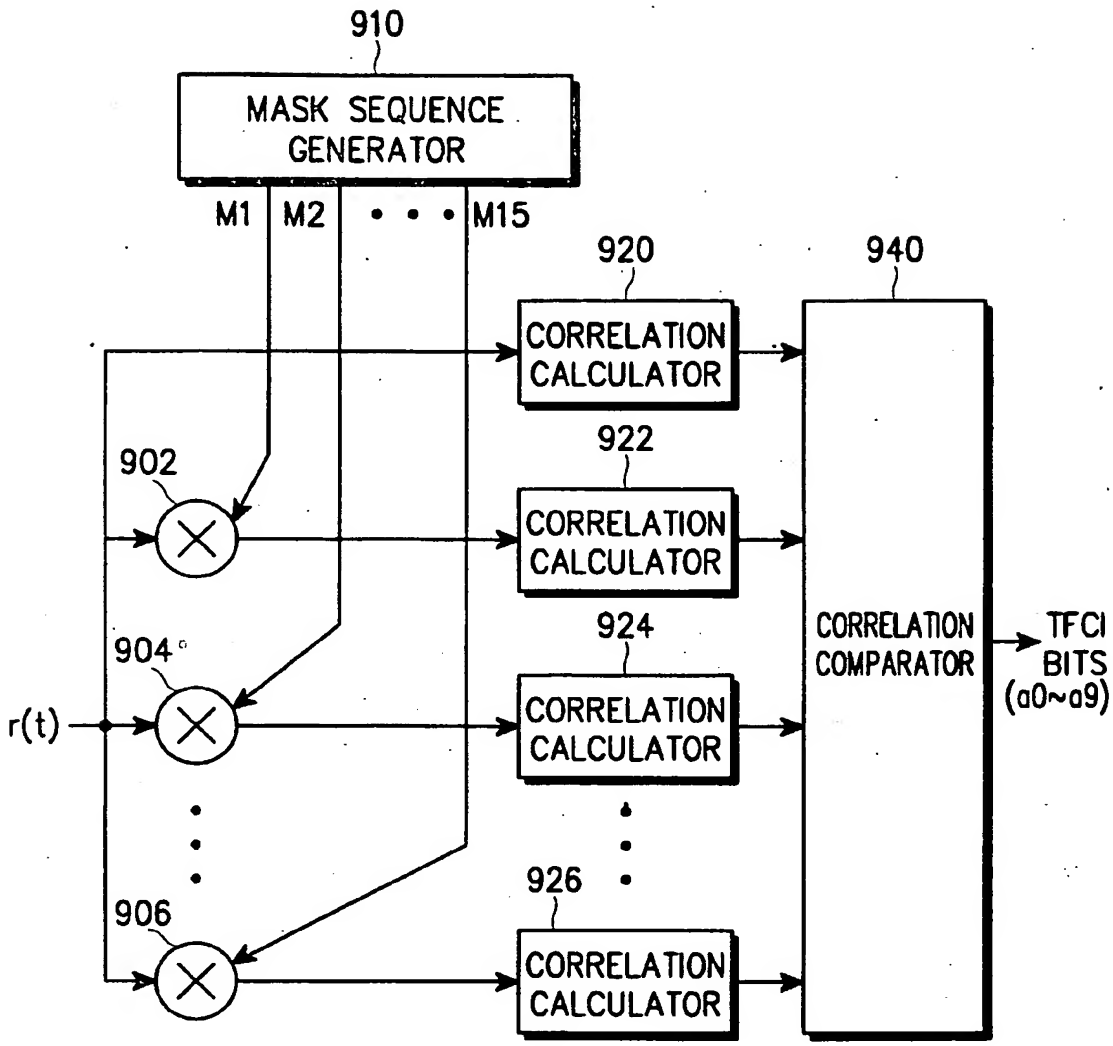

910
MASK SEQUENCE GENERATOR
M1
M2
M15
920
940
CORRELATION CALCULATOR
922
CORRELATION CALCULATOR
924
CORRELATION CALCULATOR
926
CORRELATION CALCULATOR
CORRELATION COMPARATOR
TFCI BITS (a0~a9)
902
904
906
r(t)

FIG. 9

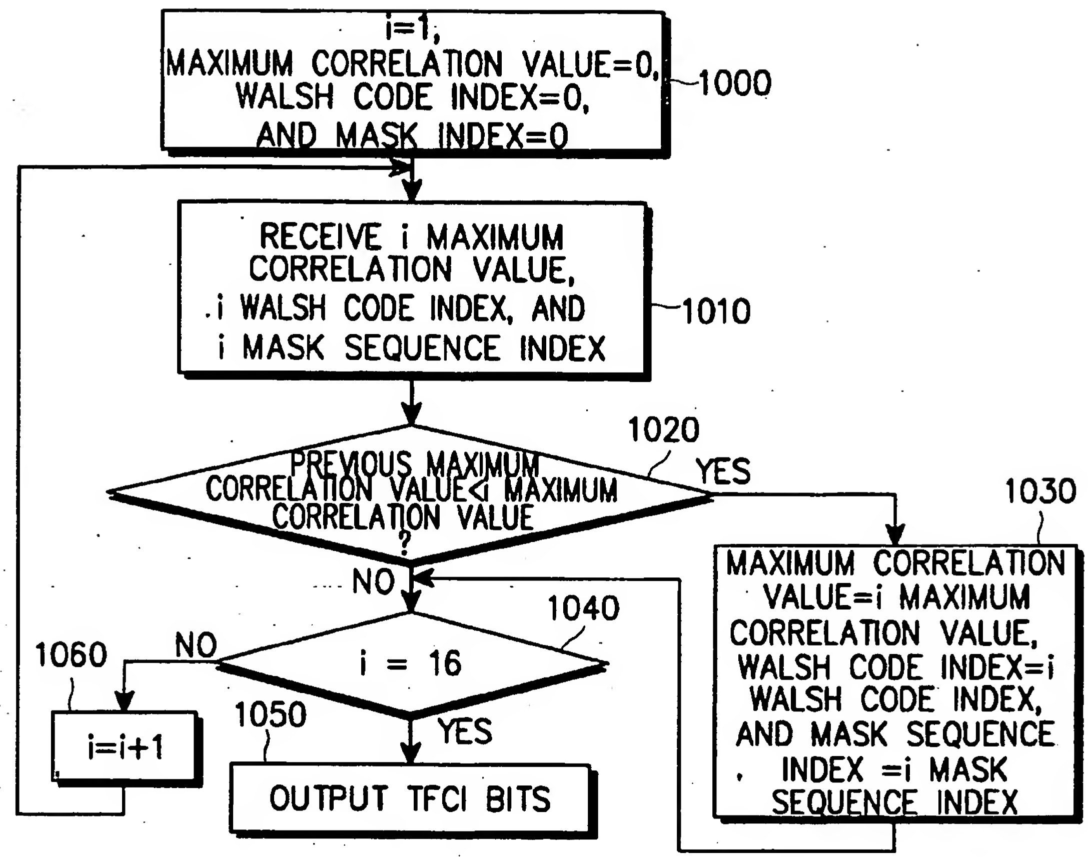

i=1,
MAXIMUM CORRELATION VALUE=0,
WALSH CODE INDEX=0,
AND MASK INDEX=0
1000
RECEIVE i MAXIMUM
CORRELATION VALUE,
i WALSH CODE INDEX, AND
i MASK SEQUENCE INDEX
1010
1020
PREVIOUS MAXIMUM
CORRELATION VALUE<i MAXIMUM
CORRELATION VALUE
?
YES
1030
MAXIMUM CORRELATION
VALUE=i MAXIMUM
CORRELATION VALUE,
WALSH CODE INDEX=i
WALSH CODE INDEX,
AND MASK SEQUENCE
INDEX =i MASK
SEQUENCE INDEX
NO
1040
i = 16
NO
1060
i=i+1
1050
YES
OUTPUT TFCI BITS

FIG. 10

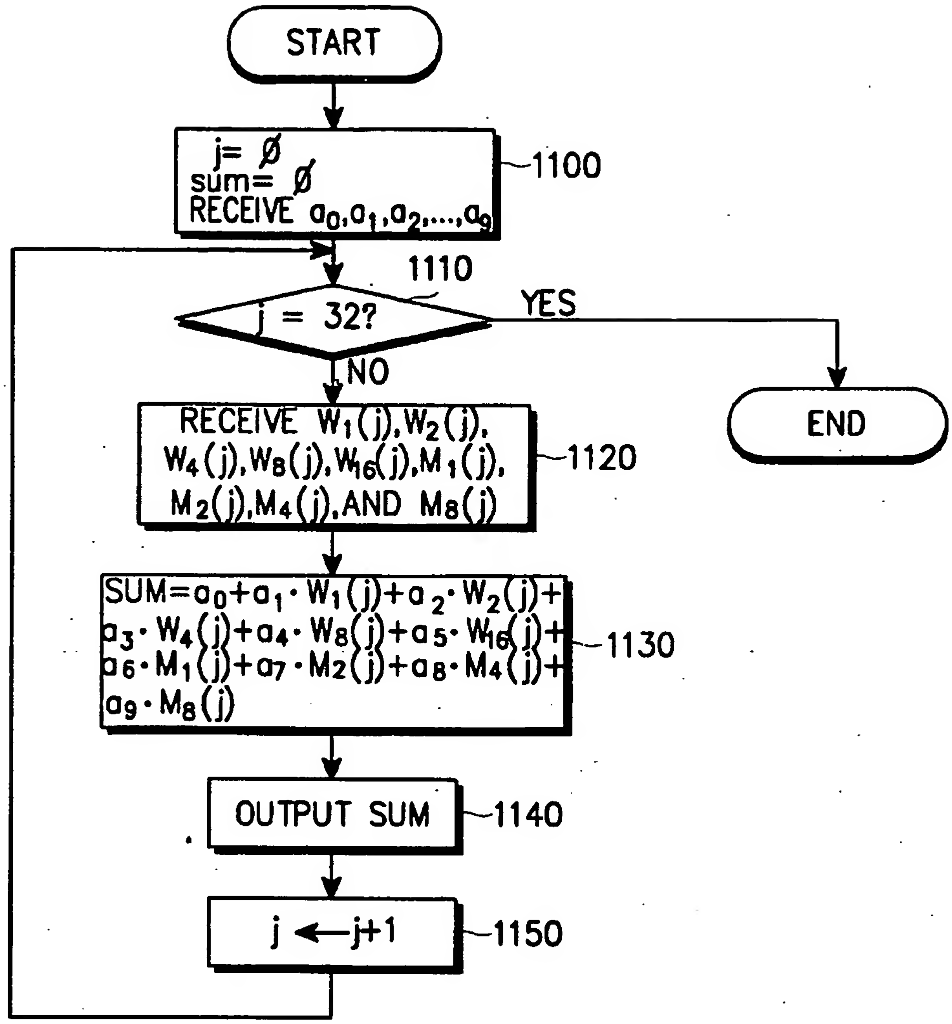

START
j= Ø
sum= Ø
RECEIVE a0,a1,a2,...,a9
1100
1110
j = 32?
YES
NO
END
RECEIVE W1(j),W2(j),
W4(j),W8(j),W16(j),M1(j),
M2(j),M4(j),AND M8(j)
1120
SUM=a0+a1·W1(j)+a2·W2(j)+
a3·W4(j)+a4·W8(j)+a5·W16(j)+
a6·M1(j)+a7·M2(j)+a8·M4(j)+
a9·M8(j)
1130
OUTPUT SUM
1140
j ←j+1
1150

FIG. 11

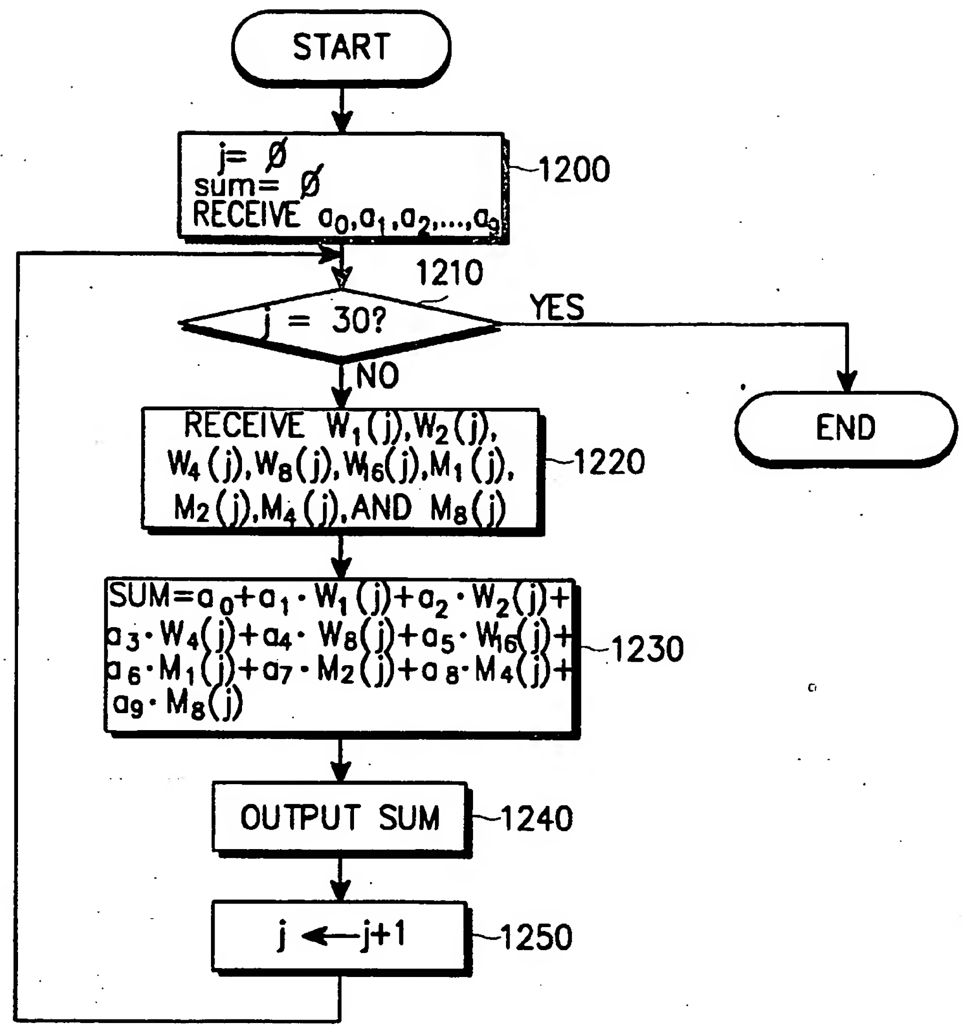

START
j= Ø
sum= Ø
RECEIVE a0,a1,a2,...,a9
1200
1210
j = 30?
YES
NO
END
RECEIVE W1(j),W2(j),
W4(j),W8(j),W16(j),M1(j),
M2(j),M4(j),AND M8(j)
1220
SUM=a0+a1·W1(j)+a2·W2(j)+
a3·W4(j)+a4·W8(j)+a5·W16(j)+
a6·M1(j)+a7·M2(j)+a8·M4(j)+
a9·M8(j)
1230
OUTPUT SUM
1240
j ←j+1
1250

FIG. 12

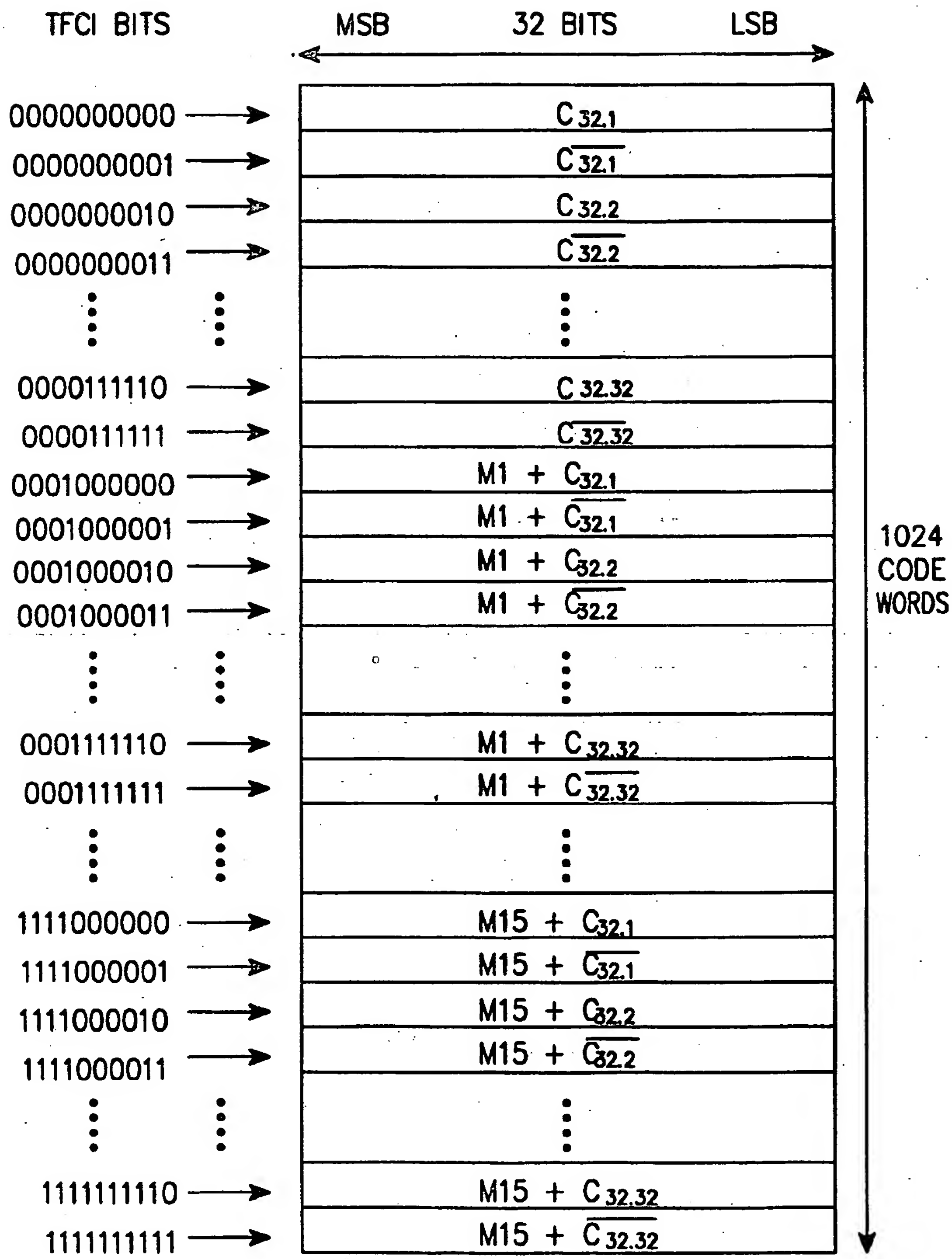

TFCI BITS
MSB
32 BITS
LSB
0000000000
0000000001
0000000010
0000000011
0000111110
0000111111
0001000000
0001000001
0001000010
0001000011
0001111110
0001111111
1111000000
1111000001
1111000010
1111000011
1111111110
1111111111
$C_{32.1}$
$C_{\overline{32.1}}$
$C_{32.2}$
$C_{\overline{32.2}}$
$C_{32.32}$
$C_{\overline{32.32}}$
M1 + $C_{32.1}$
M1 + $C_{\overline{32.1}}$
M1 + $C_{32.2}$
M1 + $C_{\overline{32.2}}$
M1 + $C_{32.32}$
M1 + $C_{\overline{32.32}}$
M15 + $C_{32.1}$
M15 + $C_{\overline{32.1}}$
M15 + $C_{32.2}$
M15 + $C_{\overline{32.2}}$
M15 + $C_{32.32}$
M15 + $C_{\overline{32.32}}$
1024
CODE
WORDS

FIG. 13

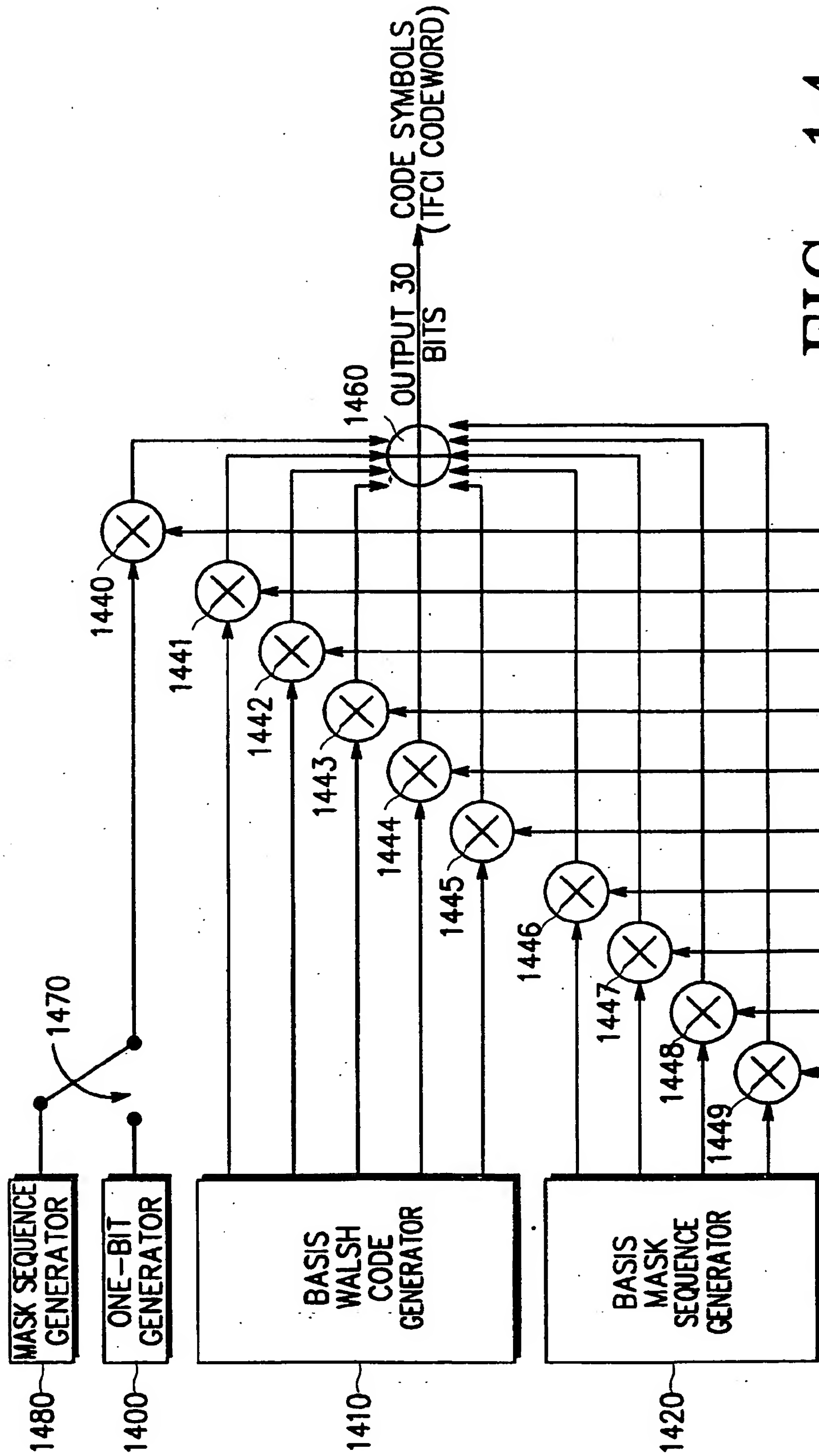

MASK SEQUENCE GENERATOR
1480
ONE-BIT GENERATOR
1400
BASIS WALSH CODE GENERATOR
1410
BASIS MASK SEQUENCE GENERATOR
1420
1470
1440
1441
1442
1443
1444
1445
1446
1447
1448
1449
a0
a1
a2
a3
a4
a5
a6
a7
a8
a9
1460
OUTPUT 30 BITS
CODE SYMBOLS (TFCI CODEWORD)

FIG. 14

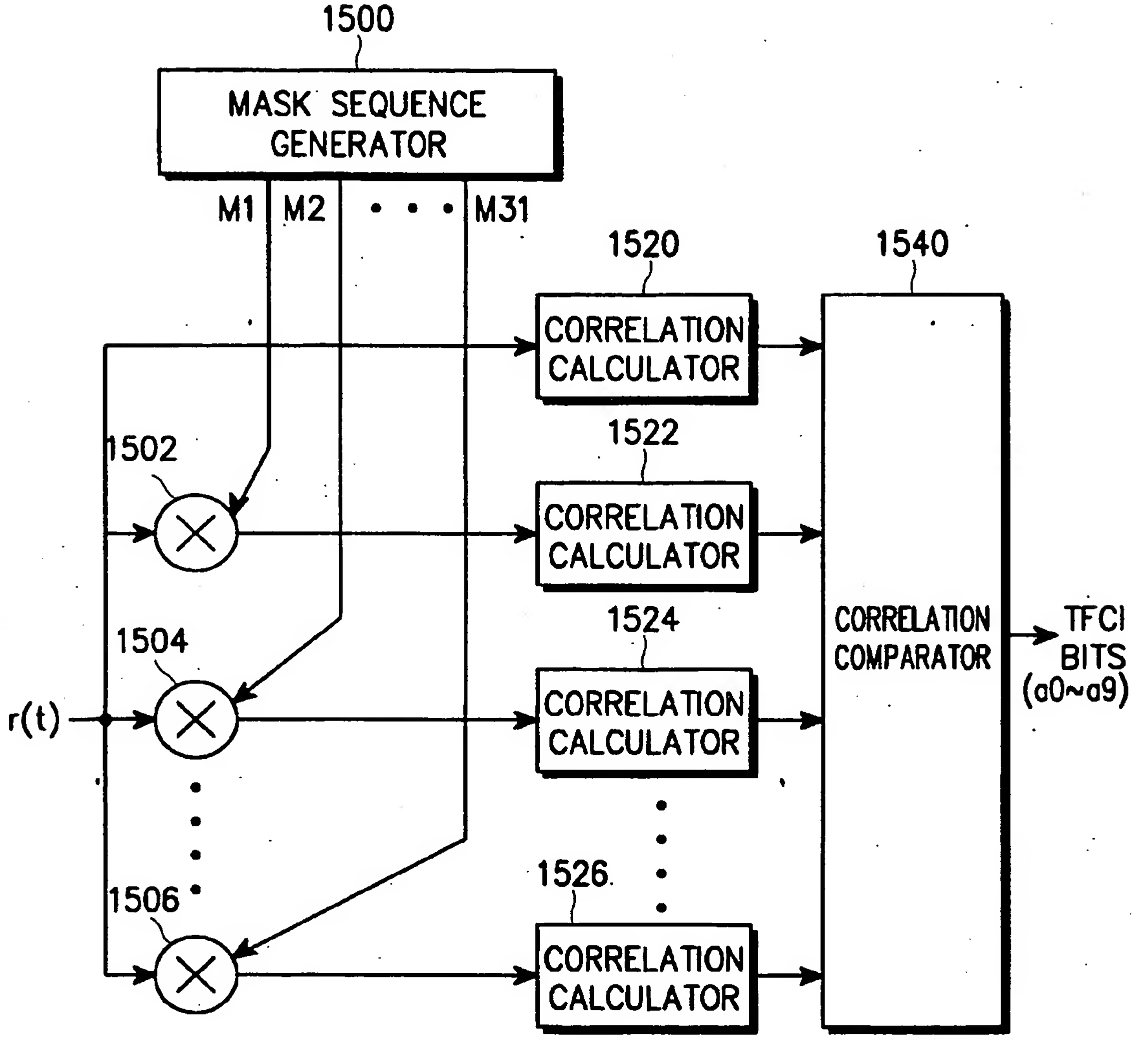

1500
MASK SEQUENCE GENERATOR
M1
M2
M31
1520
1540
CORRELATION CALCULATOR
1502
1522
CORRELATION CALCULATOR
1504
1524
CORRELATION COMPARATOR
TFCI BITS (a0~a9)
r(t)
CORRELATION CALCULATOR
1526
1506
CORRELATION CALCULATOR

FIG. 15

FIG. 16

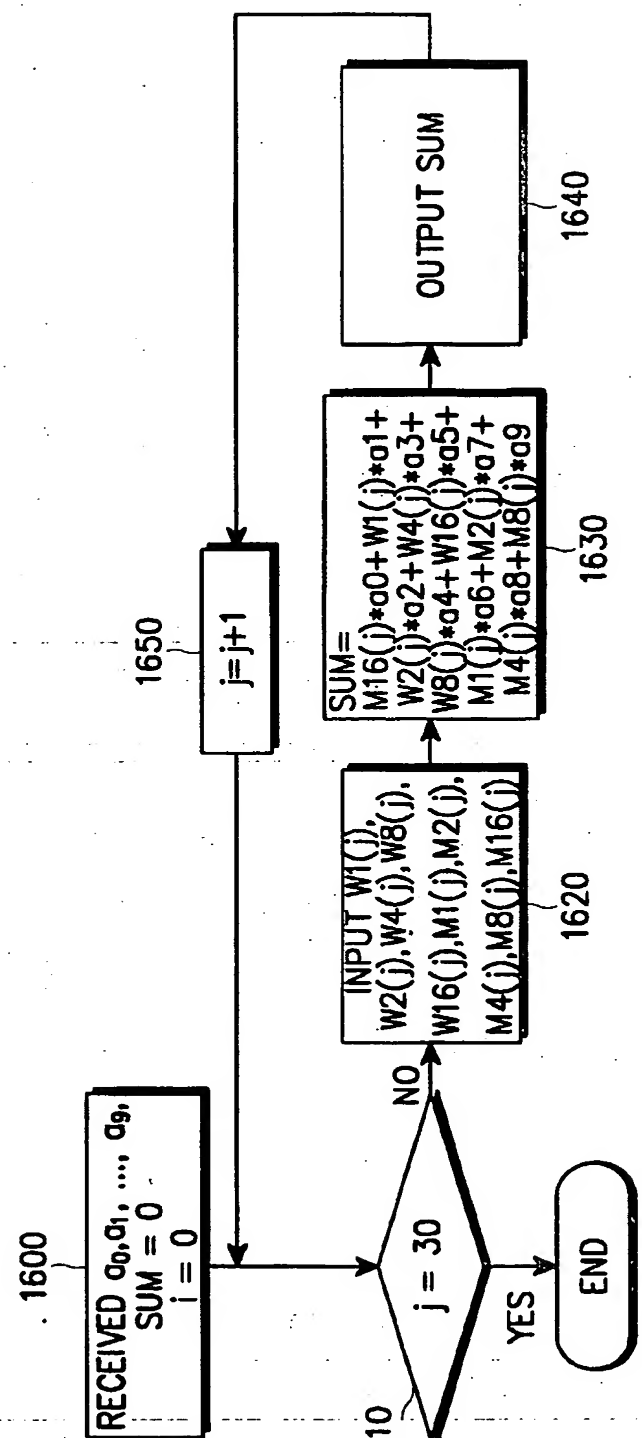
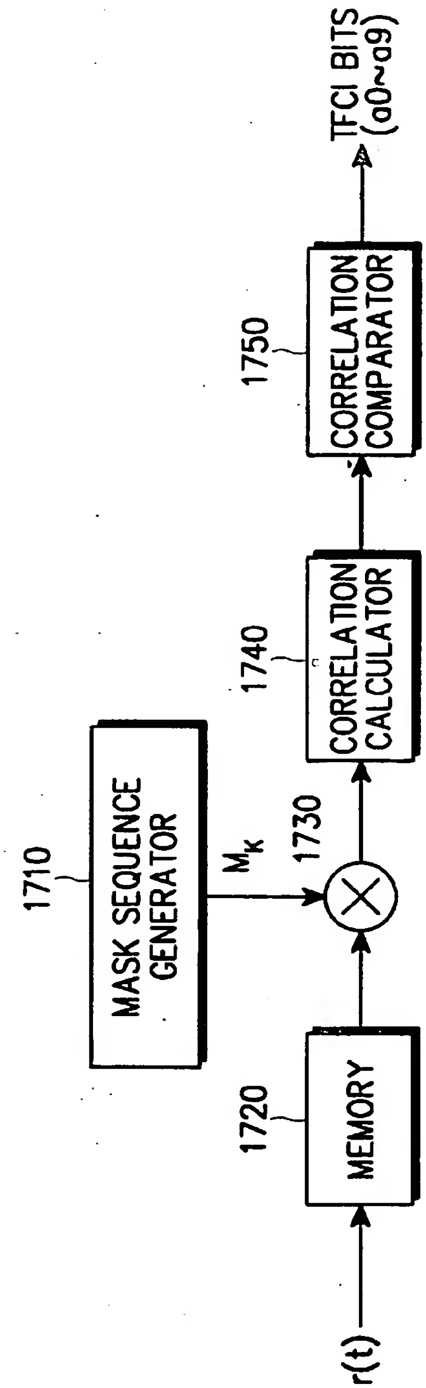

RECEIVED $a_0, a_1, \ldots, a_9$,
SUM = 0
i = 0
1600
j = 30
1610
YES
NO
END
INPUT W1(j), W2(j), W4(j), W8(j), W16(j), M1(j), M2(j), M4(j), M8(j), M16(j)
1620
SUM= M16(j)*a0+W1(j)*a1+ W2(j)*a2+W4(j)*a3+ W8(j)*a4+W16(j)*a5+ M1(j)*a6+M2(j)*a7+ M4(j)*a8+M8(j)*a9
1630
OUTPUT SUM
1640
j=j+1
1650

FIG. 17


r(t)
1720
MEMORY
1710
MASK SEQUENCE GENERATOR
M_K
1730
1740
CORRELATION CALCULATOR
1750
CORRELATION COMPARATOR
TFCI BITS (a0~a9)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR00/00731

A. CLASSIFICATION OF SUBJECT MATTER

IPC7 H04L 9/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimun documentation searched (classification system followed by classification symbols)

IPC7 H04L 1/00, 9/00,12/00 H04J

Documentation searched other than minimun documentation to the extent that such documents are included in the fileds searched

KOREAN PATENTS AND APPLICATIONS FOR INVENTIONS SINCE 1983
JAPANESE PATENTS AND APPLICATIONS FOR INVENTIONS

Electronic data base consulted during the intertnational search (name of data base and, where practicable, search trerms used)

WPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	KR 99-15261 A (ETRI) 05 MARCH 1999(05.03.1999) abstract, pgae 3, fig1	1-3
P.Y	KR 99-75942 A (DAEWOO ELECTRONICS CORP.) 15 OCTOBER 1999 (15.10.1999) abstract, page3 lines 6 to 21	1-3
P.Y	KR 99-76303 A (DAEWOO ELECTRONICS CORP.) 15 OCTOBER 1999(15.10.1999) abstract, page 3 lines 23 to 39	1-3
P. A	KR 2000-31698 A(L.G ELECTRONICS CORP.) 05 JUNE 2000(05.06.2000) fig1, page3 lines 15 to 34	1-3

[X] Further documents are listed in the continuation of Box C.   [X] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevence
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevence; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevence; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
22 SEPTEMBER 2000 (22.09.2000)	25 SEPTEMBER 2000 (25.09.2000)

Name and mailing address of the ISA/KR	Authorized officer
Korean Industrial Property Office Government Complex-Taejon, Dunsan-dong, So-ku, Taejon Metropolitan City 302-701, Republic of Korea	LEE, Son Taek
Facsimile No. 82-42-472-7140	Telephone No. 82-42-481-5667

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 565506 A(ERICSSON , GE MOBILE COMMUNICATIONS INC) 01 APRIL 1993(01.04.1993) abstract	1-3

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to part of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☒ Claims Nos.:27,32,37,etc.
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Search Authority found multiple inventions in this international application, as follows:

1. ☐ As all required addtional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be established without effort justifying an additional fee, this Authority did not invite payment of any addition fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/KR00/00731

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
KR 99-15261 A	05.03.1999	NONE	
KR 99-75942 A	15.10.1999	NONE	
KR 99-76303 A	15.10.1999	NONE	
KR 2000-31698 A	05.06.2000	NONE	
EP 565506 A	01.04.1993	AU 4026993 A	18.11.1993